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POLICY INSTRUMENTS FOR CLIMATE POLICY AND RENEWABLE ENERGY GENERATION – A COMPARATIVE LITERATURE SURVEY

Thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Technology.

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Supervisor: **Professor Pekka Pirilä**
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ABSTRACT

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There is a high degree of unanimity in both academic and political circles that a sound political climate as well as renewable energy technology intervention is needed to hinder market failures and to lead development in a more sustainable direction. However, the unanimity ends when discussion about the more precise targets and instruments begins. The primary objective of this thesis was to find and compare valuable current research about policy instruments for climate policy and renewable energy generation, as well as to screen the important question-marks in the scope, and open them up for debate. The literature review was made predominantly with the help of article collections and research tools. The focus was research from the years 2003 -2008. The paper provides an understanding of the policy backgrounds, exposes reasons behind policy choices, presents the challenging issues around the economics of climate change, proposes a selection of policy instruments, and shares with the reader a wide criteria-base for judging existing and future policies.

Some key findings could be made on the basis of the literature survey. When selecting policy instruments, the principle of "one policy, one main target" should be emphasised. Regarding international climate policy instruments, there is evidence that at least serious thought, debate and research should be given to other than current Kyoto policy instruments. In the case of renewable energy generation policy instruments, after the wise criteria weights are decided, whichever instrument or mix of instruments gives the smallest cost for consumers under these criteria should be selected. Furthermore, there is evidence that if electricity markets are further integrated in Europe, harmonised policy instruments should again be given greater emphasis. The literature also highlights that an integrated technology-focused approach should be further studied. However, whichever instrument is chosen, the success of the instrument is highly attributable to how well it is implemented.

Keywords: Climate policy, Policy instruments for renewable energy generation, Economics of climate change	**Publishing language:** English

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Ilmastopolitiikan ja uusiutuvan energiantuotannon ohjauksen tärkeydestä vallitsee laaja yhteisymmärrys niin poliittisten päättäjien kuin akateemisten tutkijoidenkin keskuudessa. Keskusteltaessa tarkemmista tavoitteista ja tavoista ohjata, tämä yhteisymmärrys alkaa kuitenkin rakoilla. Tämän diplomityön tavoitteena oli löytää ja vertailla tällä hetkellä merkittäviä tutkimuksia ilmastopolitiikan ja uusiutuvan energiantuotannon ohjauskeinoista ja samalla kartoittaa olennaisia kysymyksiä, jotka nousevat esiin aihealueesta sekä avata ne keskustelulle. Tutkimus tehtiin käyttäen apuna erilaisia hakutyökaluja ja artikkelitietokantoja. Tutkimus painotti vuosien 2003 ja 2008 välistä ajanjaksoa. Diplomityö kartoittaa ohjauskeinojen taustaa, selvittää poliittisen ohjauksen tärkeyden syitä, kertoo ilmastonmuutoksen haasteista taloustieteelle ja esittelee laajan valikoiman kriteerejä, joilla tulevia ohjauskeinoja voidaan arvioida ja analysoida.

Kirjallisuustutkimuksen perusteella voidaan nostaa esiin muutamia keskeisiä asioita. Ohjauskeinoja valittaessa tulisi painottaa ”yksi ohjauskeino, yksi päätavoite” -periaatetta. Kirjallisuudesta löytyy selviä perusteita, että kansainvälisiä ilmastopoliittisia ohjauskeinoja valittaessa tulisi tulevaisuudessa vakavasti harkita, keskustella ja tutkia vaihtoehtoja nykyisille Kioton mekanismeille. Uusiutuvan energiantuotannon ohjauksessa, kun olennaiset kriteerit on lukittu, tulisi valita se ohjauskeino tai ohjauskeinojen yhdistelmä, joka tuottaa kyseisiä kriteerejä noudattaen pienimmät kustannukset asiakkaalle. Lisäksi kirjallisuus osoittaa, että mikäli Euroopan sähkömarkkinat tulevaisuudessa yhdentyvät, tulisi ohjauskeinojen harmonisointia ryhtyä jälleen vahvasti painottamaan. Integroituja teknologiakeskeisiä ohjaustapoja tulisi jatkossa tutkia laajemmin. Mihin ohjauskeinoon ikinä päädytäänkin - tärkeintä ohjauskeinon toimivuuden kannalta on, kuinka hyvin sen toteutuksessa onnistutaan.

Avainsanat: Ilmastopolitiikka, Uusiutuvan energiantuotannon ohjaus, Ilmastonmuutoksen taloustiede	**Julkaisukieli:** Englanti

Foreword

I was delighted to have the chance to write my Master's thesis and thus learn more on a challenging topic of policy instruments for climate policy and renewable energy generation. Many thanks must go to those people who made my thesis possible and supported me through the writing process.

First of all I wish to thank this thesis financier, which was the Environmental Pool, coordinated by "Energiateollisuus ry" i.e. the association of Finnish Energy Industries, for making this study possible in the first place, as well as my supervisor, Professor Pekka Pirilä, for giving me the opportunity to work in such an exciting area. To him I also owe great thanks for support, advice, and feedback. Additionally, I would like to thank my instructor, Mr. Jukka Paatero, for his continuous support and feedback when instructing my thesis. I would also like to thank Mr. Charles Baldwin and Mr. William Moore for their huge help with proofreading.

Special thanks should also be dedicated to the members of the Laboratory of Energy Economics and Power Plant Engineering at the Helsinki University of Technology for creating a fun and supportive environment in which to work.

Lastly, thanks are directed to the VIPs of my life, to the nearest and dearest people. My family, friends, and especially Annica - thank you all for your help, support and presence - without you all this would mean nothing.

Espoo 14 April 2009

Heikki Siniharju

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Abbreviations

BATNEEC:	Best Available Techniques Not Entailing Excessive Costs
BAU:	Business As Usual
CDM:	Clean Development Mechanism
CEP:	Common Energy Policy
COP:	Conference of Parties
CO2:	Carbon Dioxide
CT:	Carbon Trade
EC:	Emission Certificate or European Commission
EKC:	Environmental Kuznets Curve
EU:	European Union
EMAS:	Eco-Management and Audit Scheme
EPE:	Energy Plan for Europe
ETS:	Emission Trading Scheme
FCCC:	Framework Convention on Climate Change
FIT:	Feed-in Tariff
GC:	Green Certificate
GDP:	Gross Domestic Product
GHG:	Greenhouse Gas
IEA:	International Energy Agency
ISO:	International Organisation for Standardization
IPCC:	Intergovernmental Panel on Climate Change
JI:	Joint Implementation
kWh:	Kilowatt hour
MWh:	Megawatt hour
NFFO:	Non-Fossil Fuel Obligation
OPEC:	Organization of the Petroleum Exporting Countries

PBF:	Public Benefit Fund
PURPA:	The Public Utility Regulatory Policies Act
PTC:	Production Tax Credits
REC:	Renewable Energy Certificate
RES:	Renewable Energy Source
RET:	Renewable Energy Technology
RO:	Renewable Obligation
RPS:	Renewable Portfolio Standard
TCE:	Transaction Cost Economics
TWh:	Tetrawatt hour
UN:	United Nations
UNCCC:	United Nations Climate Change Conference
UNEP:	United Nations Environmental Program
UNFCCC:	See UN and FCCC
WMO:	World Meteorological Organisation

1 Introduction

There is an increasing scientific consensus that rising concentrations of carbon dioxide (CO2) and other greenhouse gases (GHG), which originate from the burning of fossil fuels, are gradually warming the Earth's climate. The degree of damage associated with this warming remains uncertain, but there is a risk that it could be large, irreversible, and possibly catastrophic. The major greenhouse gas CO2 is a global pollutant; a ton of emissions from any point on the globe would have the same effect on the atmospheric concentration of CO2 and would thereby result in the same amount of possible damage (Congressional Budget Office 2008, Nordhaus 2008, Stern 2007, Sterner 2003). Hence we need international climate policy.

Policy instruments for climate policy and renewable energy generation are closely interconnected. Together, they are both seen as important from the environmental viewpoint and might have a strong effect on economic and social wellbeing. Equally, depending on their design, they may either boost or lower each other's functionality. Nevertheless, the usage of these policy instruments should not be seen as substituting one for the other, as they work towards different goals. Hence they should rather be seen as complementary.

In this respect, renewable energy generation incentives are accentuated, because the utilisation of renewable energy generation is seen to have advantages relative to conventional methods. Energy security is currently emphasised heavily and GHG emissions reduction has gained more and more focus. Furthermore, the exploitation of local and decentralized energy sources and stimulation of innovative industries are in the spotlight.

Above all, the new renewable energy generation methods have not achieved a level where they are profitable in the open electricity market. Hence credible positive transition to their use would need to be supported with different policy instruments. This support can be justified because technological development has the phenomenal characteristics of a positive externality and it might bear remarkable fruit in the long-run.

Strategies to enhance climate policy and renewable energy generation are at this moment key issues in the field of energy policy and have attracted much attention in the media. Finnish goals in energy policy and those of other European Union (EU) member countries are strongly guided by adjustment to EU-level decisions, which have proved to be challenging, and the realisation of which may require actions entailing significant costs. When the costs of required actions as well as non-action might become high, it is crucial that they are estimated, implemented, evaluated, improved, and monitored prudently. Bad implementation, myopia, and stubbornness might diminish the good behind any actions taken and cause among other things carbon leakage, local unemployment, inferior technology lock-in, and diminished enthusiasm for more efficient approaches.

There is a broad range of international research concerning policy instruments for climate policy and renewable energy generation. Many of the research studies that have been found to be important also contain significant inconsistencies one with another. It is thus evident that essential questions still remain unresolved. The goal of this thesis is to find and compare the valuable research on the scope of policy instruments for climate policy and renewable energy generation, and to highlight the essential questions and inconsistencies that emerge from the literature review.

1.1 Problem Formulation

The purpose of this thesis is to increase the understanding of theoretical as well as empirical effects, functionality, and interaction of policy instruments for climate policy and renewable energy generation respectively. The main research problems addressed by this thesis are thus formulated as follows: what kind of research has been made concerning the effects, functionality, and interaction of policy instruments for climate policy and renewable energy generation, and what are the present essential questions and proposed answers arising from the broad field of reference at our disposal?

The main research problem is approached through the following sub-problems:

- Why do we need policy instruments for climate policy and renewable energy generation?
- What kind of academic debate is going on regarding the economics of climate change?
- According to existing research, what are the most suitable suggestions for international climate policy instruments?
- According to existing research, what are the most suitable suggestions for renewable energy (power) generation incentives?
- What are the suitable criteria for judging policy instruments for climate policies and renewable energy generation, and how widely have they been used in the international research?

1.2 Objectives of the Thesis

Firstly, this thesis seeks to find and compare the valuable research about policy instruments for climate policy and renewable energy generation. The second objective is to highlight essential questions that emerge from the scope of the research presented below, and to compare the academic research carried out about the questions. Last but not least, the paper seeks to find important issues that may need further examination inside the terms of reference of the study. In order to reach these objectives, the history and the reasons for the policies are presented as a background. Relevant instruments are described and the broad output of academic research is presented. This should give the reader a good understanding of the current basis of climate policy, why renewable energy and climate policies are implemented, and what are the pros and cons of present policy instruments that the academic research has highlighted. In addition, the reader should gain an understanding of how climate policies and renewable energy incentives are connected and interact, how climate policies and renewable energy incentives have been investigated before, and what kind of questions are being discussed in the field at the present.

1.3 Scope of the Thesis

The scope of this thesis is limited to climate policy issues within the international and EU-wide climate policies, leaving out national solutions. Furthermore, only international or EU-wide emission trade, carbon tax, and hybrid policy instruments are emphasised.

Renewable energy generation policy instruments are first and foremost studied in the EU context, although examples and references are also taken from other continents. Renewable power generation issues and questions are strongly emphasised. Even though quite a few viewpoints can be generalized to concern energy generation as a whole, it should be remembered that power generation and energy generation (heat included) are not synonyms. Furthermore, the policy debate is highly narrowed to concern debate between feed-in tariff and green certificate issues.

In this research, incentives are in the first place examined from the climate policy and renewable energy generation viewpoints. Results might also hold relevance with the energy generation's reliability and quality, which are taken into consideration but are not stressed.

1.4 Definitions and Abbreviations

This thesis employs several important terms and definitions. In the international literature on the subject, terms and definitions vary substantially. The policy instruments have different names in different countries, even though the basic functioning might be similar. To be able to understand them correctly and not get lost with different definitions, it is important to know the starting points. To minimise the possibility of getting mixed up, a selection of terms and definitions are used in this thesis. The most important terms and definitions are presented below in alphabetical order. Furthermore, abbreviations of the commonly used terms are presented on page VIII.

Climate Change: This thesis follows the definition of climate change of the United Nations (United Nations 1992) and defines it as *"a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods"*.

Discounting: Basic formula (1/(1+i)^n). Discounting involves two related and often confused concepts. One is the idea of a discount rate on goods, which is a positive concept that measures a relative price of goods at different points of time. This is also called the real return on capital, the real interest rate, the opportunity cost of capital, and the real return. The real return measures the yield on investments corrected by the change in the overall price level. The second important discount concept involves the relative weight of the economic welfare of different households or generations over time. This is sometimes called the pure rate of social time preference. It is calculated in percent per unit time, like an interest rate, but refers to the discount in future welfare, not in future goods or dollars. A zero time discount rate means that future generations into the indefinite future are treated symmetrically with present generations; a positive time discount rate means that the welfare of future generations is reduced or "discounted" relative to nearer generations (Nordhaus 2007a).

Emissions: In this thesis, emissions are defined as *"the release of greenhouse gases and/or their precursors into the atmosphere over a specified area and period of time"* (United Nations 1992). Emissions therefore only include those of greenhouse gases (GHG), and exclude e.g. waste and solid emissions.

Emission Trading Scheme: Common name for different market mechanisms, which are trading emission permits or allowances. The idea of emission trade is to execute the emission abatement actions where it is most cost-efficient. (Huutoniemi, Estlander et al. 2006)

Externality: "*A cost or benefit that arises from production of a good or service and falls on someone other than the producers, or a cost or benefit that arises from consumption of a good or service and falls on someone other than the consumer*" (Parkin, Powell et al. 2005).

Policy: A plan or course of action, as of a government, political party, or business, intended to influence and determine decisions, actions, and other matters (Pickett, et al. 2000). Furthermore, policy is defined to be the common principles by which a government is guided in its administration of public affairs (Thomson, Lehman 2005).

Scarcity rent: The rent that accrues to the owner of a natural resource just because it is scarce. Thus, with increasing scarcity of the natural resource or similarly other good, the value of that good must accrue at the same rate as for other financial instruments, or else the owner would not keep the good but sell, hence lowering the price (Sterner 2003, Hotelling 1931).

1.5 Research Methodology

The research methods used in this thesis are literature review and my own evaluation. Literature review was predominantly made with the help of ScienceDirect articles collection, Helsinki University of Technology Library's Nelli information research portal, the ISI web of science reference research tool, and Google Scholar literature research tool. Literature was collected before October 2008, though a few new articles were added to the list afterwards. The focus of the literature survey in on research made between the years 2003 -2008. The reason was not to underestimate any earlier research work, but to narrow the amount of data and to get a good focus on what kind of issues are under the closest examination right now.

First the articles were chosen according to keywords, which included: climate policy, renewable energy policy, feed-in tariff, green certificate, carbon tax, emission trade, and economic incentives or policy instruments towards both climate policy and renewable energy.

Secondly, the discovered journals, books, and reports were analysed against the frame of reference that was initially as broad as present international climate policy instrument options and renewable energy generation policy options. From this wide array of data, presently relevant questions were sought out and as a result, the compared Chapter 7 issues where selected. These issues were chosen using the criteria of "volume of research" and "future potential", meaning which issues were in the centre of the debate and which issues might have future importance in the debate. Thereafter the scope was narrowed accordingly.

1.6 Structure

The content of this thesis is as follows: Chapter 1 presents the objectives and scope of the thesis as well as the methodology followed for data gathering and analysis. In Chapter 2 a background to climate policies and energy generation incentives is presented. Also a quick review of the status quo and upcoming expectations (primarily from the Finnish point of view) are presented.

Chapter 3 gives an introduction to the need of policy instruments for climate policy and renewable energy generation, and Chapter 4 introduces the international academic debate on climate change economics. The policy instruments for climate change and renewable energy generation were gathered to Chapter 5, after which the important criteria for the evaluation of the research are presented in Chapter 6. The relevant research concerning the issues found was grouped in Chapter 7. The issues were then analysed against the criteria and different academic studies were compared. Chapter 8 concludes and summarises the work done and gives recommendations about future work in progress.

2 Background Information

This chapter describes how international climate policies and energy generation policies have been evolving historically, especially from the European perspective. It would be hard to understand the present if we were not to scrutinise what has happened in the past. When choosing policy instruments, as well as in other aspects of life, such things as history, traditions, culture, habits, and expectations enter into the selection process (Sterner 2003). How a country or international community started its policymaking might impact powerfully on its decision making today. This is sometimes called path dependency (Toke, Lauber 2007). Amending policies and legislation are huge processes. Hence even when new knowledge is available speaking on behalf of changing course, it might be hard to move fast enough. Change takes time.

2.1 Short history of international climate policy

Before any problem can be resolved, we must first know what the problem is and learn how to understand and deal with it. As we can see from Figure *1*, scientists understood the phenomena behind climate change before the end of the 19th century (Huutoniemi, Estlander et al. 2006). In fact, Arrhenius, as presented in the table below, was not even the first to define the phenomenon. A French scientist called Joseph Fourier introduced the concept already in 1824 (Pirilä 2000). From that point on it took a long time to launch international cooperation to mitigate climate change. Climate change debate started at the end of the 1950s and from the year 1970 onwards the issue was highlighted in many international scientific and political conventions (Huutoniemi, Estlander et al. 2006).

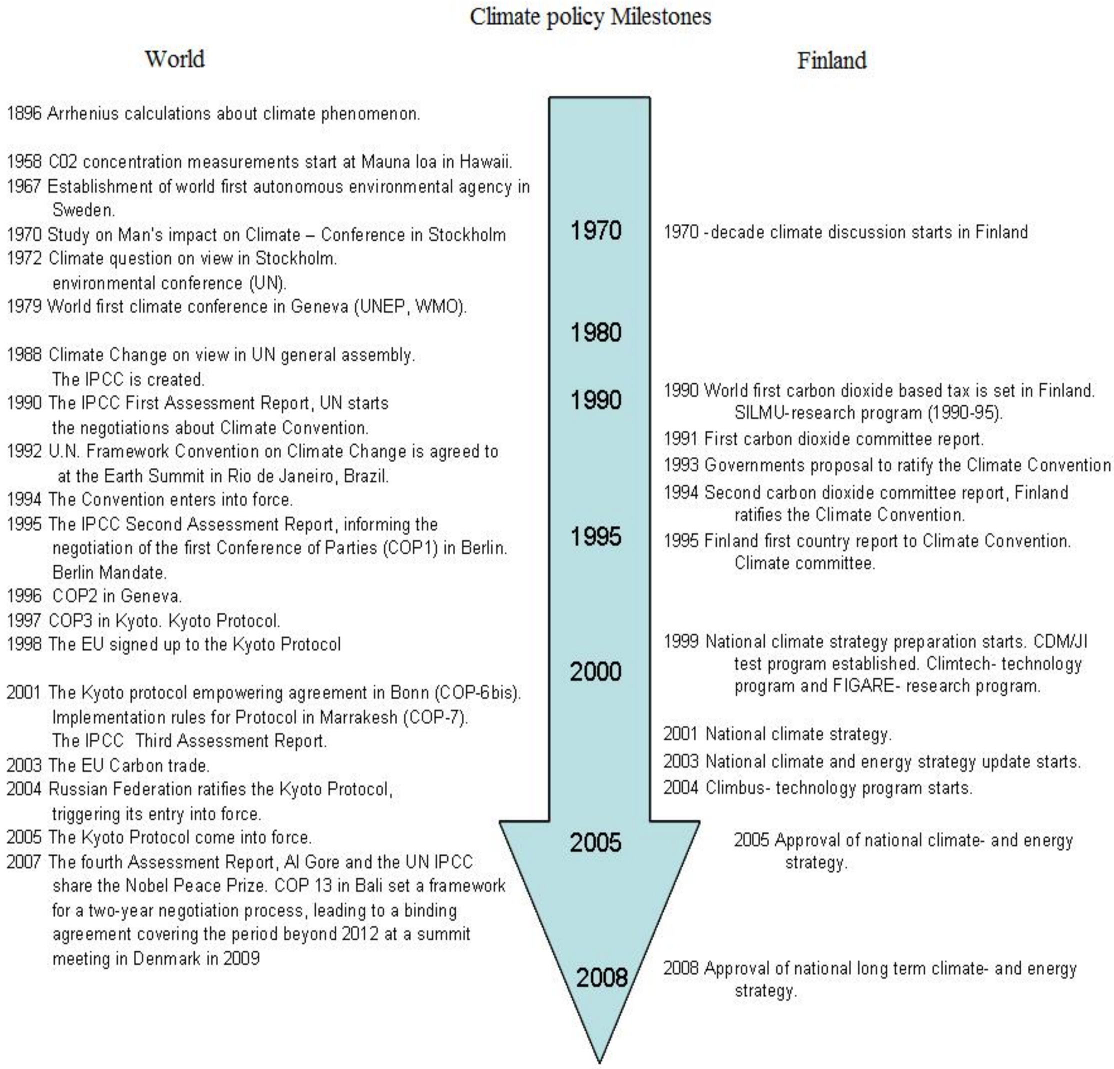

Figure 1: Climate Policy Milestones.[1]

After 1988 things started to happen slightly faster. In 1988 the United Nations Environmental Program (UNEP) and the World Meteorological Organisation (WMO) established the Intergovernmental Panel on Climate Change (IPCC), which produces regular scientific and technical assessments on climate change (Huutoniemi, Estlander et al. 2006).

At the United Nations Conference on Environment and Development, held in Rio de Janeiro, Brazil, agreement was reached on the Framework Convention on Climate

[1] Figure strongly imitates one presented in (Huutoniemi, Estlander et al. 2006).

Change (FCCC) that established as its ultimate objective the *"stabilization of greenhouse-gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with climate system"*. As a temporary step, the FCCC imposed a non-binding goal which advocated reducing of greenhouse gas emissions by Annex I[2] counties to their 1990 levels by the year 2000 (Aldy, Barrett et al. 2003). The Convention has received nearly universal membership, with 192 countries having ratified it thus far (UNFCCC 2008a).

The FCCC was further strengthened in the third Conference of Parties (COP3) in Kyoto, Japan in 1997, when the Kyoto Protocol was adopted. The Kyoto Protocol entered into force on 16 February 2005, after the Russian Federation ratified it in late 2004. 183 Parties to the Convention have ratified its Protocol to date. (UNFCCC 2008a)

As we can see from Figure *1*, Finnish national climate policy and research has partly followed international developments. The Finnish Research Programme on Climate Change (SILMU) opened connections to international research cooperation and created a foundation for future research programmes (Huutoniemi, Estlander et al. 2006). After the Carbon Dioxide Committee's[3] reports I&II, Finnish climate policy has been strongly connected with energy policy and vice versa, especially during the first years of the 21st century. One noticeable milestone for Finns was that Finland enacted a carbon tax in 1990**,** the first country to do so. A further characteristic feature of the current decade has been that Finland has followed the climate policy goals and main lines devised in the European Commission (EC).

In 2000 the European Commission (EC) established an initiative known as the European Climate Change Programme, whose key goal was to ensure that the EU meets its Kyoto

[2] These include the developed nations plus economies in transition; precise list of the Annex I countries in Appendix 1.

[3] The Carbon Dioxide Committee 1 was established by the Ministry of the Environment (from 1990 to 1991), to examine possibilities and guidelines for mitigating future Finnish greenhouse gas emissions.

target (European Commission 2008). In October 2003 the European Union Emission Trading Directive was established.

At present the main focus is directed to debate on what will happen after 2012, post Kyoto. During the United Nations Climate Conference (UNCCC) COP 13 in Bali in December of 2007 a unanimous decision was reached that launched negotiations on strengthened international action on climate change after Kyoto. Negotiations should be set to conclude in December 2009 in the fifteenth COP, to be held in Copenhagen (UNFCCC 2008a, Valtioneuvosto 2008).

2.1.1 The Kyoto Protocol

The main feature of the Kyoto Protocol is that it sets binding targets for 37 industrialized countries and the European Union (Annex B countries[4]) for reducing greenhouse gas (GHG) emissions. Reductions amount to an average of five per cent against 1990 levels over the five-year period 2008-2012. The detailed rules for the implementation of the Protocol were adopted at COP 7 in Marrakesh in 2001, and are called the "Marrakesh Accords." Under the Treaty, countries must meet their targets primarily through national measures (UNFCCC 2008a).

However, the Kyoto Protocol offers them an additional means of meeting their targets by way of three market-based flexibility mechanisms. These are emission trading, joint implementation (JI), and the clean development mechanism (CDM). The emission trading mechanism allows Annex B countries to trade part of their target emissions with one another. Joint implementation allows Annex B countries to cooperate on projects and transfer emission allowances on the basis of such projects. Furthermore, the CDM allows Annex B countries to finance projects in non-Annex B countries in exchange for credits towards meeting their own emission reduction targets (Aldy, Barrett et al. 2003).

[4] Annex B countries and their emission targets are listed in Appendix 2.

2.2 Energy Generation Policy in Europe

The orientation of official energy polices, and the balance of other policies affecting energy policy, has shifted over the decades. For much of the post-war period, there was an emphasis on fostering national energy resources and managing the transition to a more diverse energy balance, based on the concern for energy security (McGowan 1996). The energy crisis of the 1970s and the emergent realisation of the global scarcity of environmental resources, especially oil, boosted great concern in many western countries about their energy supply structure. President Jimmy Carter gave a speech in April 1977 where he said: "With the exception of preventing war, this (the energy crisis) is the greatest challenge our country will face during our life time." Energy crisis was the big spark that spurred research into technologies for saving energy and for alternative methods of producing energy. In many countries it also boosted the systematic national subsidising of these technologies in the name of energy security. For example in 1974 the European Council adopted a programme that prioritised getting energy from as many different sources as possible (CIVITAS 2008). In Denmark it triggered the well-known wind energy development, and boosted nuclear power implementation in many European countries as well.

More recently, the emphasis in general energy policy discussion, especially in the media, has shifted from energy security and the strategic importance of energy to environmental concerns and climate policy (McGowan 1996). In reality, the decision-making is still heavily focused on the national energy security agenda. Nevertheless, on paper, the three cornerstones that appear in almost every EU or national report concerning energy are sustainability, security, and competitiveness (Valtioneuvosto 2008, Commission of the European Communities 2008). How to balance these three is an extremely great challenge.

2.2.1 Case Finland

For Finns, in the field of energy generation the most important policy instrument has been energy taxation. Finland enacted a carbon tax in 1990, and was the first country to do so. While originally based only on the carbon content of fuels, it was changed to a combination of carbon and energy tax in 1997. This weakened the position of those electricity generation methods that had been untaxed before 1997. These generation forms were then subsidised. Beyond 1997 the general structure has remained unchanged (Ministry of the Environment 2008).[5]

In addition to the tax policy instruments, the Finnish Government has also used investment and clearance grant instruments. These grants are distributed to companies, corporations, and municipalities to help them with project investments and surveys that have furthered energy conservation, made energy production and usage more efficient, promoted the production and use of renewable energy, and helped to secure and diversify the energy supply (Hiltunen 2004).

As with climate policy, Finnish 21st century energy policy has often followed the lines decided in the European Commission (EC). In Finland, the national climate strategy was adopted in 2001. For the following few years the climate and energy policy was based on that strategy. However, during 2003 the operating environment changed quite drastically and the Government decided to renew the strategy so that it takes into account the contents of the EU emission trading directive and the Kyoto mechanism (Valtioneuvosto 2005). Hence in 2005 the new climate and energy strategy was implemented.

Since the 2005 report, the international and EU climate and energy policy objectives and obligations changed once again to such an extent that, in 2007, a policy position was set down in the Government Programme of Prime Minister Vanhanen's second Cabinet. The long-term Climate and Energy Strategy - Government Report to Parliament was delivered on 6 November 2008. The main objectives of the strategy were similar to those of the EU: environmental sustainability, security of supply, competitiveness of energy supply (Valtioneuvosto 2008).

[5] Appendix 3 presents Finnish energy tax rates.

2.2.2 EU Directives and Propositions for Directives

Finnish climate and energy strategy and targets are strongly directed by the European Union and its objectives. Tables *1* and *2* describe those directives and proposals for directives that are in place in the fields of greenhouse gas and renewable energy sources.[6]

Table 1: Greenhouse Gas Directives and Proposal for Directives (November 2008)

Directive/Proposal Code:	**Content:**
Directive 2003/87/EC	Scheme for greenhouse gas emission allowance trading within the Community. (Emission Trading Scheme Directive)
Directive 2004/101/EC	Directive for establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms. (Link Directive)
Decision 280/2004/EC	Decision concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol.
Commission Proposal COM(2008) 16	Proposal for a Directive amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading system of the Community.
Commission Proposal COM(2008) 17	Proposal for a Decision on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020
Commission Proposal COM(2008) 18	Proposal for a Directive on the geological storage of carbon dioxide and amending Council Directives 85/337/EEC, 96/61/EC, Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC and Regulation (EC) No 1013/2006, (CCS-directive)

Table 2: Renewable Energy Source Directives and Proposals (November 2008)

Directive/Proposal Code:	**Content:**
Directive 2001/77/EC	Directive of the European Parliament and the Council on the promotion of the electricity produced from renewable energy sources in the international electricity market (RES-E Directive)
Directive 2003/30/EC	Directive on the promotion of the use of biofuels or other renewable fuels for transport
Commission Proposal COM(2008) 19	Proposal for a Directive on the promotion of the use of energy from renewable sources, (RES-Directive)

[6] The above proposals for directives were approved with changes in the European Parliament's plenary session of 17 December 2008. Modifications are under construction and some decisions are postponed until 1 January 2013. Important decisions concerning force majeure will be decided later by the European Commission. Force majeure means a possibility to revaluate the achieving of the targets later on, if insuperability obstacles occur (Commission of the European Communities 2008, Elinkeinoelämän Keskusliitto 2009a).

Directives are allocating the direction for associated member states and at the same time tightening up the free space in which EU members can navigate with their own policy instruments. Under the heaviest political debate right now are the new proposals for directives that the Commission released in January 2008 on both greenhouse gas emission reductions and renewable energy promotion.

Essential objectives that concern the EU's energy and climate strategy are:

- An overall bidding target of a 20% share of renewable energy sources in energy consumption by 2020 in the EU (this was 8.5% in 2005). This target burden would be divided between member states so that for example the Finnish share of renewables would be 38% by 2020 (it was 28.5% in 2005) (Valtioneuvosto 2008).

- A 10% binding minimum target for biofuels in transport to be achieved by every member state (Valtioneuvosto 2008). The share of biofuels in EU member states in 2005 was about 1% (Commission of the European Communities 2006).

- At the same time, to enhance energy efficiency by 20% compared with the baseline by the year 2020. This target is not binding, but directive (Valtioneuvosto 2008).

- The EU makes a firm independent commitment to achieve at least a 20% reduction of greenhouse gas emissions by 2020 relative to 1990. The objective would rise to 30% if a global and comprehensive agreement for the period beyond 2012 is reached. The other developed countries should commit themselves to comparable emission reductions and the economically more advanced developing countries should commit themselves to contributing adequately according to their responsibilities and capabilities (Valtioneuvosto 2008).

These objectives are easy to spot in the Finnish Long-term Climate and Energy Strategy of 6 November 2008. The strategy clearly proves that the objectives proposed by the European Commission for Finland regarding the reduction of emissions, promotion of renewable energy, or enhancing the efficiency of energy consumption cannot be attained without new, significant climate and energy policy measures (Valtioneuvosto 2008). The more precise objectives for these policies were:

- Cutting the emissions according to what is necessary in future EU and international conventions. That is, at this moment, according to the Commission's proposal Finland should - by means of national measures - cut emissions by an average of 16 per cent from the 2005 level, by 2020 (Valtioneuvosto 2008).

Without new energy policy measures (the baseline) this would be 90 million equivalent carbon dioxide tonnes in 2020. In 2005 it was 69 million equivalent carbon dioxide tonnes (Tilastokeskus 2008). This huge gap and challenge would need the above- and below-mentioned strategies. It is also highlighted that 2005 is a "bad" benchmark year for Finns because we had a mild winter, a good year for rainfall, and furthermore a lengthy paper industry strike that shut down the paper mills for several months[7].

- Aggregate energy consumption 310 tetra watt hours (TWh) and electricity consumption 98 TWh in 2020 (Valtioneuvosto 2008).

The baseline aggregate consumption of energy would be 350 TWh in 2020 (Valtioneuvosto 2008). Year 2007, Finnish aggregate energy consumption was about 411 TWh and electricity consumption was 90.4 TWh (Tilastokeskus 2009). In order to attain the objectives set, the efficiency of energy consumption must be enhanced, particularly in housing, construction, and transport (Valtioneuvosto 2008).

- To offer sufficient, moderately priced electricity sourcing that supports climate objectives (Valtioneuvosto 2008).

In future, electricity sourcing should continue to be based on a diverse system. The emphasis will be placed on plants that do not emit greenhouse gases, or ones with low emissions, such as combined power and heat plants using renewable fuels, and financially profitable and environmentally acceptable water and wind power plants. A decision-in-principle as per the Nuclear Energy Act on the additional construction of

[7] This was amended to be calculated from the average emissions in years 2005, 2006 and 2007, and thus Finland received 20% more CO2 allowances compared with the above case (Elinkeinoelämän Keskusliitto 2009b).

nuclear energy generation could be necessary in the next few years (Valtioneuvosto 2008).

- To increase the share of renewable energy to 38 per cent by 2020.

The baseline would be 31% in 2020. In order to stimulate a shift to renewable energy usage, the current support and steering systems will be intensified and structures changed. Indeed, meeting the obligation would require an intense increase in the use of wood-based energy, waste fuels, heat pumps, biogas, and wind energy. As a new method for promoting renewable energy, a cost-effective feed-in tariff system, operating on market terms as far as possible, will be introduced (Valtioneuvosto 2008). The feed-in tariff (FIT) system has been quite popular in other EU member states, and the next sub-chapter will introduce the frequency of FIT and other systems inside the EU.

2.3 Present Renewable Energy Generation Policies in Europe and US

In the field of energy, the practical policy implementation remains mainly a national task, while the broader frames or boundary conditions of energy policy are increasingly elaborated internationally. For example in the case of Europe by the European Union, within the western industrialised countries by the International Energy Agency (IEA), globally by the World Trade Organisation or the UN, or through the supply and demand conditions in energy trade by producers' networks, among others the Organization of the Petroleum Exporting Countries (OPEC) or the Nord Pool electricity exchange (Lund 2007).

The same mantra applies with policy instruments for renewable energy generation. Even though there has been discussion of harmonisation of renewable policy instruments inside Europe, the practical policy implementation has still remained a national cause. Related to this, the instrument assortment is quite wide, as we will observe in Chapter 5. In spite of the wide selection, the main discussion at present focuses on the comparison of two instrument systems. These are feed-in tariffs (FIT) and the quota regulation in combination with a tradable green certificate (TGC) market. As we can see from Figures

2 and *3*[8] these are the dominant policy instruments for renewable electricity generation in Europe.

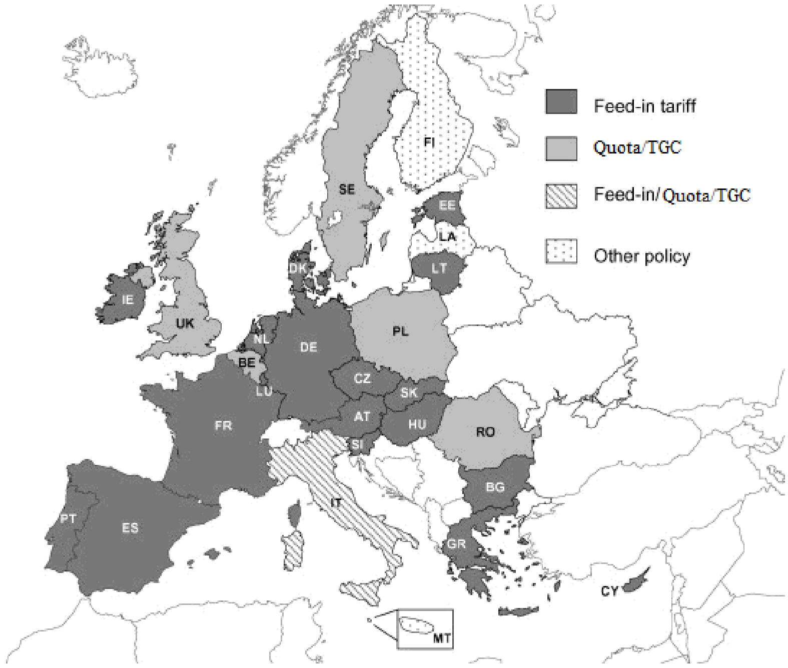

Figure 2: Renewable Electricity Policies in EU Member States as of February 2007 (Rickerson, Sawin et al. 2007)

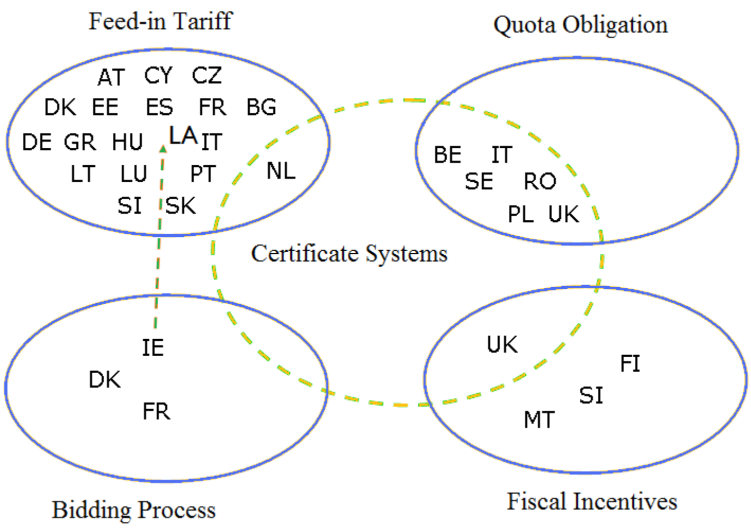

Figure 3: Overview of Primary Renewable Electricity Policies in EU Member States[9]

[8] There are a few differences between Figure 2 and 3 because of the timing (for example Latvia).

[9] Based on (Reece 2008) and (Morthorst, Jensen 2007).

As Figure *3* indicates, other policy schemes such as bidding processes are still used, though no longer as a dominant policy scheme in any EU country. Finland and Malta are the only countries that employ tax incentives and investment grants as a primary scheme.

In the United States the primary policy instrument is renewable portfolio standard (RPS), as displayed in Figure *4*, which shows the utilization and the goals of the scheme. This is the United States version of the tradable green certificate (TGC) scheme used in Europe. As we can see, the goals and structures between different states are variable. This is also the case with the climate policy. Even though the United States Government has rejected mandatory targets for curbing emissions under the Kyoto Protocol, many of the states, cities, and regional partnerships have taken the initiative and set their own programmes and targets to cut greenhouse gases (GHG) (Byrne, Hughes et al. 2007).

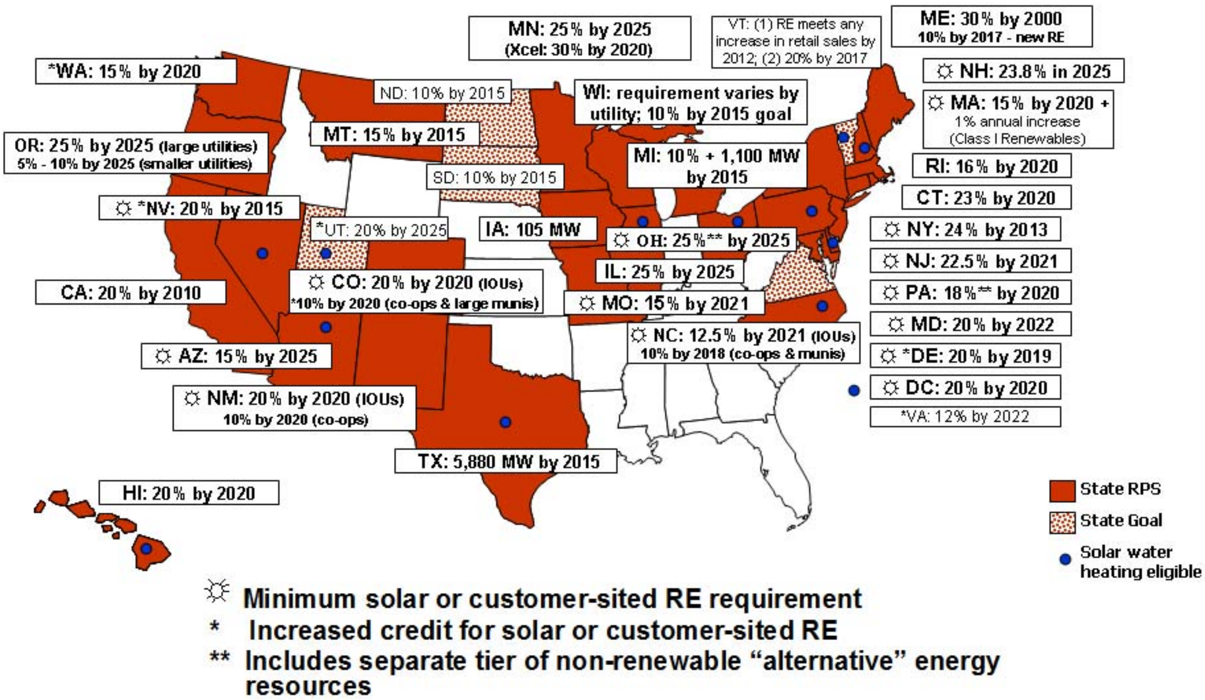

Figure 4: United States State Renewable Portfolio Standards (RPS) Utilisation Map (North Carolina State University 2008)

When we diversify the examination of the use of different policy instruments we find that with these primary policy instruments a wide range of policies are used as supplementary as well as in the form of a portfolio approach, both in Europe and in the

United States. This is nicely demonstrated in Table 15, located in Appendix 4. Table 15 summarises all the different rules, regulations, and policies used in different states, cities, and utilities in the United States to promote renewable energy. Support options vary from public benefit funds (PBFs) to construction and design. There is a noticeable difference between different states as to which kind of instruments are used and how much. The situation is the same in Europe and around the world[10]. Several different primary and supplementary instruments are used.

[10] For a good summary of renewable energy promotion policy implementation around the world, see (REN21 2007).

3 The Need for Sound Policy Instruments

This chapter will attempt to answer a number of questions. Why is it that social, economic, and ecological factors do not find the balance on their own? Following from this, why should we balance economic priorities with environmental dangers? And why is it that Adam Smith's "invisible hand" will not take care of the balance between the economy and the environment, nor does it? The focus here is on the need for climate policies and renewable energy generation policies especially from the electricity generation viewpoint.

The energy crisis of the 1970s and the emergent realisation of the scarcity of environmental resources caused great concern in many western countries about their energy supply and as to how economic growth could be kept up. Later on, the emergence of the climate change phenomenon has given rise to great alarm, because we seem to be gradually warming the Earth's atmosphere. Even though the degree of damage associated with warming remains uncertain, there is a risk that it could be large, irreversible, and possibly even catastrophic (Congressional Budget Office 2008) (IPCC 2007a). Hence it is understandable that when human actions might cause catastrophic and irreversible damage and or change the direction of development, common principles and actions might be needed.

3.1 The Big Picture

Nonetheless, these two great concerns are just a part of the bigger picture. The population and economic growth of humankind has reached such a volume that its impacts on ecology are evident all over the world. Besides population and economic growth, another major determinant of the human impact on the ecosystem is our choice of technology[11] (Sterner 2003).

At one extreme, some researchers stress that economic development and growth have already surpassed the sustainable level of activity on earth (Meadows, Meadows et al. 1972). At the other extreme, some researchers trust that demand caused by increased population and per capita income can be nourished with technical progress (Kahn, Brown et al. 1976). Either way, this growth has already led to scarcity of some ecological goods that are needed for the mere existence of their property rights and market values[12](Sterner 2003). The problem is that these market values do not always follow the real value of the environmental good and that the valid rights do not equally take into account either human or environmental rights.

Furthermore, technological development intended to enhance the condition of the human race does not always work in the best possible way and it might have unintended and unpredicted negative ecological, economic, and social consequences. In the 1960s, Rachel Carson's book "Silent Spring" (1962) sparked discussion on the downside of technology that was intended to better human life. This also had a powerful impact in waking up the general public to an understanding that the activities of man are also affecting our natural environment profoundly - and probably even irreversibly.

Because humankind has had a strong impact on nature and vice versa, it has become more and more evident that to be able to maximise our "total" wellbeing, especially in the long run, we have to nourish economic and social wellbeing as well as our environment's ecological wellbeing.

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[11] This concept is handily summarized by the I=PAT equation, whereby human impact on ecosystem is determined by population, affluence, and technology (Ehrlich, Holdren 1971).

[12] Market values are caused by the scarcity. See scarcity rent in definitions and abbreviations, Chapter 1.4. For more about economic treatment of scarcity and allocation of scarce resources over time, see (Sterner 2003, Hotelling 1931).

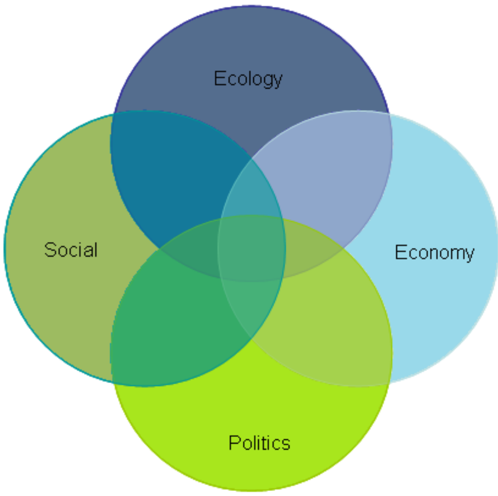

Figure 5: Different Priorities of Society; Economy, Social, Ecological Interaction with Politics[13]

This balance is well described by Figure *5*. The reason why politics and policy instruments are added to the figure is that sometimes these three other factors will not find the optimal balance to maximise the "total" wellbeing on their own. In such a case political intervention might be needed to balance the situation.

This balance between economic, ecological, and social wellbeing and the possible need for intervention is especially necessary in sustainable development. This idea is neatly summarised by the World Commission on Environment and Development report, also known as the Brundtland Report, which states: "*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (World Commission on Environment and Development 1987) .

3.2 The Optimal Starting Point

Economists regularly assume that wellbeing of an individual (i) can be described as a utility (U) function that depends on income, environment, leisure, consumption, and

[13] Figure imitates the one presented in (Pirilä 2000).

other factors. Analogously it is often assumed that social welfare (W) consists of all these individual utilities, and forms the welfare function:

$$W(U1,\ldots Ui,\ldots Un) \quad (1)$$

The shape of these functions is typically unknown, and to be able to maximise welfare several value judgements are needed. Some people might prefer an egalitarian society, while others a more egoistic one. Some might emphasise that the welfare of future generations should be included and stressed as well as distributional viewpoints and concerns about long-term sustainability. Even though there is conflict between different values, welfare maximisation is still a general goal for most purposes (Sterner 2003). Hence finding the maximum that would qualify for everyone in the short and the long run is an optimal goal to reach.

3.2.1 **Perfect Market**

The key lesson of economics is that the market mechanism is efficient at allocating resources. There are two fundamental theorems of welfare economics. The first states that any competitive equilibrium leads to an efficient allocation of resources. Models point out that under perfect conditions, a market will automatically achieve a Pareto optimal[14] outcome (Sterner 2003). This theorem is often taken to be an analytical verification of Adam Smith's "invisible hand" hypothesis. The theorem strongly supports a case for non-intervention in ideal circumstances; in other words, let the markets do the work and the outcome will be desirable without any control of policy instruments and suchlike.

This view is also adapted in environmental Kutznets curves (EKCs) that are often associated with economy and its development over time. The idea behind this curve is that with economic growth, emissions typically follow the inverted "U" curve as

[14] "Pareto optimality is an efficiency concept that implies that the economic situation of one individual can be improved only if the economic situation of another individual is worsened" (Sterner 2003). For a more in-depth overview see (Musgrave 1959).

illustrated in Figure 6. The usual rationale behind this curve is that in the early phases of economic growth there will be inevitable growth in emissions, but as income increases, emissions peak and then decline. Thus, a strict belief in EKCs would lead us to accept as true that emission increases were unavoidable in the short run and the damage would automatically be reversed later (Sterner 2003).

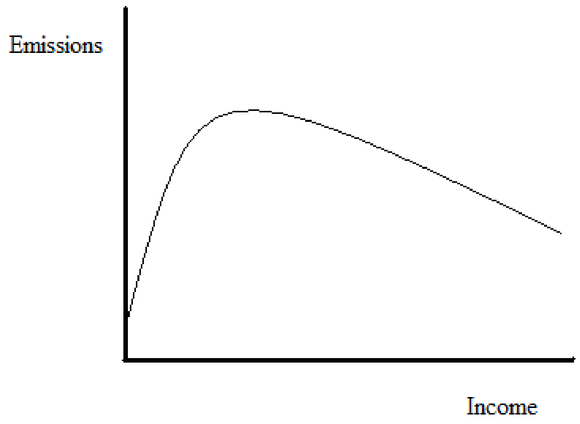

Figure 6: A hypothetical Environmental Kuznets Curve.[15]

Thus, it is suggested that increase of emissions and destruction of natural resources do not matter, because the damage would be automatically reversed. See for example research by (Schmalensee, Stoker et al. 1998) for more insight on emissions following this path.

However, this kind of view might be dangerous, because experience shows that "replacing" natural resources and "repairing" ecosystems is much more expensive than disaster prevention, and in certain cases the damage from emissions might be irreversible. It should also be noticed that in the case of greenhouse gas emissions, when some societies become richer they might want to improve their own environment, but they can only do a little for international climate change by reducing their own emissions. Other societies, especially those near the left-hand end of the income axis, still have little they can do in any respect (Sterner 2003, Stern 2007).

[15] Based on figures in (Stern 2007) and (Sterner 2003).

The second theorem of welfare economics states that any efficient allocation can be sustainable by a competitive equilibrium. Hence it implies that in the case that the state arranges the appropriate conditions, any outcome can be decentralized. In other words, it can be achieved by the market agents by themselves. It stands for the re-allocation of money by taking it from some individuals and giving it to others, though otherwise leaving the economy intact (Sterner 2003). These kinds of redistributions are in our special interest when investigating policy instruments. Instruments like taxes and subsidies distort the market and influence people's behaviour, and thus do not always work in practice, but in some cases they can redistribute and decentralise wealth as well as wellbeing (Sterner 2003).

3.3 Market Failure

Theory and reality do not always meet. A textbook example, which needs a "perfect market" to be functional, meets in reality an imperfect world. Figure 7 summarizes some factors that are needed to make our welfare theorems work. Even with a casual look we realize that those requirements do not hold in the real world. In the real world we therefore encounter several market failures.

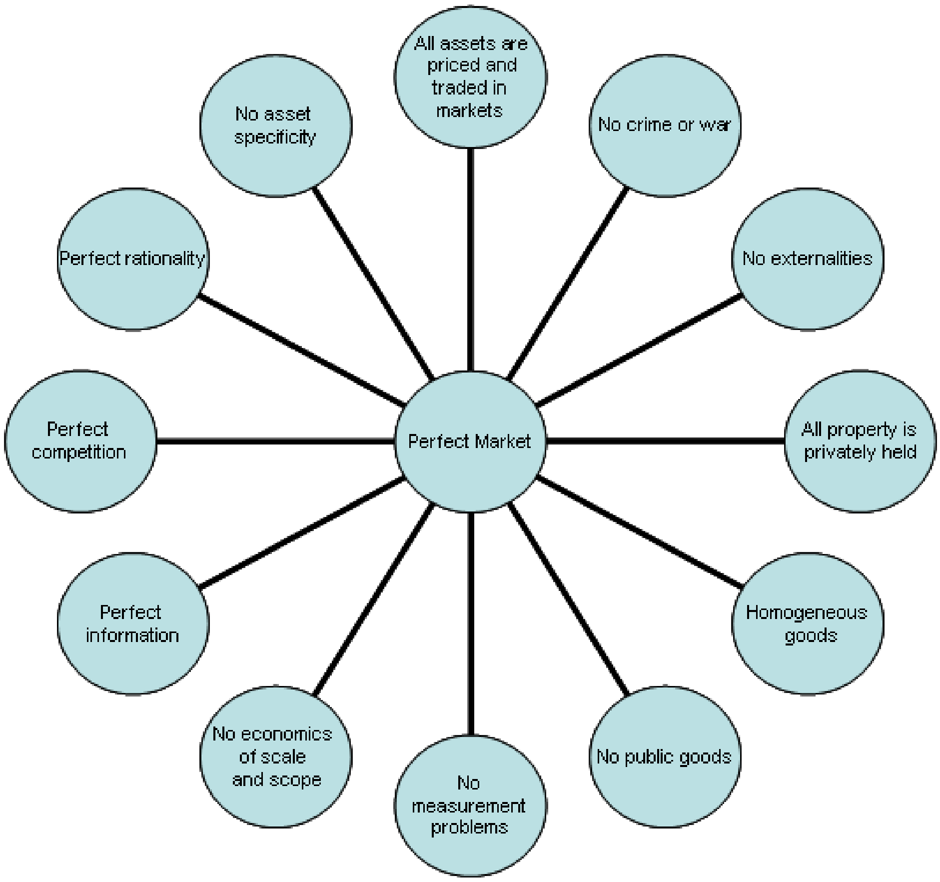

Figure 7: Perfect Market Requirements

Market failure is a technical term that roughly refers to situations under which the free market does not produce optimal welfare. It is thereby a failure compared with the abstract model economists create of a perfect market economy. Such failures include externalities, public goods, poorly defined or defended rights, common pool resources, non-competitive markets, asymmetric information, policy failures, and institutional failures (Sterner 2003).

Externalities are non-market side effects of production or consumption. An external cost is a cost borne not by the producer but by other people. For example, when an electricity power company burns coal to generate electricity, the action causes air pollution and imposes a real cost for the economy through among other things pulmonary diseases and acid rain. The company does not consider the cost of pollution when it decides on the quantity of electric power it has to supply. If externalities are not internalized, supply is based on production cost only, not on the cost that it inflicts on others. As a result an agent produces more power than is the efficient quantity (Parkin, Powell et al.

2005). Even though most external effects are quite hard to calculate, Table 3 below describes an estimation of negative external costs that are caused by electricity production in the EU member states. It is these costs that markets do not efficiently add to electricity prices. These estimated values are very high, as can be seen for example in the case of Belgian coal and lignite power production, where the external costs may be as great as 15 € cents (EUR 0.15). In comparison, the average industry electricity prices in Europe are 9.59 € cent per kWh (Goerten, Clement 2008).

Table 3: External Costs for Electricity Production in the EU (In € cent per kWh[16])[17]

Country	Coal & lignite	Peat	Oil	Gas	Nuclear	Biomass	Hydro	PV	Wind
Austria				1−3		2−3	0.1		
Belgium	4−15			1−2	0.5				
Germany	3−6		5−8	1−2	0.2	3		0.6	0.05
Denmark	4−7			2−3		1			0.1
Spain	5−8			1−2		3−5 [18]			0.2
Finland	2−4	2−5				1			
France	7−10		8−11	2−4	0.3	1	1		
Greece	5−8		3−5	1		0−0.8	1		0.25
Ireland	6−8	3−4							
Italy			3−6	2−3			0.3		
Netherlands	3−4			1−2	0.7	0.5			
Norway				1−2		0.2	0.2		0−0.25
Portugal	4−7			1−2		1−2	0.03		
Sweden	2−4					0.3	0−07		
United Kingdom	4−7		3−5	1−2	0.25	1			0.15

[16] Sub-total of quantifiable externalities (such as global warming, public health, occupational health, material damage). Results are by their very nature location- and technology-specific, and therefore no simple generalisations are possible. Only subtotals are available, as not all impacts have been assessed completely. Assumptions and parameters included in the analysis may be specific for the fuel cycle, technology, or location. Assumptions and parameters have changed over time, reflecting the state of the art at that time.

[17] Adapted from (European Communities 2003)

[18] Biomass co-fired with lignite

Another form of externality is external benefit or *positive externality.* It occurs when a company for example creates a new innovative technology or invests in energy generation reliability. Others might also benefit from that in the form of a "spillover". Because knowledge can be easily copied once it has been created, innovators cannot receive the full benefits of their investment in the creation of that knowledge. This is because buyers do not take into account the benefits that this product has for others. In this way, produced quantity will fall short of the efficient quantity (Jaffe, Newell et al. 2005, Foxon, Pearson 2008).

In sum, climate policy is interested in the case of internalizing negative externality, whereas the renewable energy generation policy tries to find ways to deal with the positive one, in the form of subsidies, for instance.

Public goods are products or services that are consumed by everyone, even if they do not pay for them. For example, clean air or enforcement of the law. The market tends to undersupply these goods because of the free-rider problem, mainly because it is hard to exclude those who do not pay. *Common pool resources*, on the other hand, are resources that nobody owns and anyone can use, such as the fish in the ocean, firewood, or fodder (Parkin, Powell et al. 2005). Free-riding, and other mechanisms that lead to the undersupply of public goods, may also lead to overexploitation of common pool resources, at least if institutions are not strong enough to intervene with appropriate policy instruments (Sterner 2003).

In the field of electricity generation there has been much talk about *non-competitive markets*. Where monopolies and oligopolies exist, the usual result is a non-optimal supply. Too little may be sold at too high a price. In some cases, like in electricity distribution lines, it is common to have natural monopolies, because it would serve nobody's interest to have multiple lines. Nevertheless, to be able to control pervasive prices, policy instruments may yet again be needed.

Of all the market failures, *asymmetric information* is perhaps the most pervasive. Hence understanding information asymmetries goes to the heart of the most essential dilemma: how to promote social goals like abatement of climate change and energy security without destroying incentives for work and efficiency. For instance, if policymakers do not have reliable data on emission damages and abatement cost, they cannot design policies that are both efficient with respect to resource allocation and fair in sharing the burdens of all costs involved. Thus, if policymakers need the cooperation of individuals who have “inside” information, they must accept that those individuals may require that they get something in return (Sterner 2003).

3.4 Rights from the Point of View of Climate Policy

Rights, politics, and policy instruments are interlinked in ways that vary between economies. One descriptive everyday illustration of rights is cigarette smoking (Sterner 2003). A few decades ago, individuals had the right to smoke almost everywhere they pleased, and they still do in some countries. People who suffered from the effects of second-hand smoke had no alternative but to try to avoid smokers. Over time, information and awareness have increased and have changed this situation so much that today in some countries the rights has been reversed: individuals have the right to enjoy a smoke-free environment. The use of instruments such as tobacco taxes, prohibition of tobacco advertising, no-smoking zones, and law suits against tobacco companies has strongly affected the general perception of rights regarding cigarette smoking as well as the functioning of the tobacco industry. Hence we can observe that some policy instruments demand changes in individual rights, whereas other policy instruments can also help to change the structure of rights by changing ethical and moral perceptions (Sterner 2003).

One way to scrutinise especially negative externalities is that they can be seen as the consequences of incomplete rights: if air would have owners with a right to clean air, then those owners could sue those who caused the air pollution and thus internalize the effects. The same hypothetical game could be used with positive externalities. The trouble with this approach is that many costs and profits are hard to estimate and in rights models many of them overlap one another. For example, one person’s right to build a wind turbine on his property limits a neighbour’s right to enjoy an aesthetic environment. Furthermore, when we add the rights relationship not only between human beings but also between humans and nature, things become even more complicated.

3.5 Market inadequacy

Past experience has shown that pure market forces, even though effective in resource use, have mainly too short-sighted a perspective to work out sufficient solutions to the long-term energy and climate challenges ahead (Lund 2007). Technological advances such as in the field of renewable energy technology are seen as one of the most important tools for fighting climate change. This is stressed time and again in international research. Scenario analyses by IPCC (IPCC 2007a) and Shell International Limited (Shell International Limited 2001) suggest for example that rapid increases in new renewable energy will be crucial to a successful global response to climate change. Furthermore, particularly those who preach most intensively in the name of technology salvation are looking forward to back-stop technology, which stands for technology that might resolve the energy problem and/or the climate change problem once and for all (Nordhaus 2008).

Nevertheless, often potential new technological innovations are not able to penetrate to the market because they are not cost-effective. This is not seen as a market failure as long as scarcity rent and abatement costs are added to prices. As we have seen above, quite often they are not added. Other barriers also cause market inadequacy; in this case especially imperfect information and path dependency causes lock-in failures to enter the stage.

Decisions we make are never path-independent. They are often steered by the choices that we have made before. This path dependence, leading to lock-in of existing technologies and so forth, arises because of system or network externalities, combined with the fact that technologies are closely liked to their economic and social environment (Foxon, Pearson 2008). In this way, new technologies must compete not only with components of an existing technology, but also with the overall system in which it is embedded. A further point is that the established companies may have high market power to safeguard their position (IEA 2003, Foxon, Pearson 2008). This is particularly highlighted in the fossil fuel case, and has been called carbon lock-in.

Because the future is uncertain and companies lack perfect knowledge, what is known and how it is known becomes central in the innovation process (Foxon, Pearson 2008). If technological learning is not given an opportunity, market forces might underestimate a potentially important new technology that could bring people a huge amount of wellbeing in the long run. This is because they are staring among other things at the present cost-effectiveness. Hence if there are no other ways than the mainstream market for the new potential technology to penetrate and develop itself by learning and with the help of economies of scale[19], it might be passed over.

When we consider for example new renewable energy technology competing against ignorance, technology lock-ins, and so forth, we have to add to this equation also the double barrier that is caused by the market inadequacy of internalizing the negative as well as the positive externalities (Jaffe, Newell et al. 2005). Hence this situation might require policy instruments to generate incentives for new technologies and to overcome the obstacles created by the prevalence of more incumbent technology.

3.6 Institutional and Policy Failure

Even though polices should be implemented to help achieve positive goals there exists the possibility that they may function in the opposite fashion. This end-result is especially common in the situations where policies are implemented to help certain goals, but where they may have catastrophic effects on other goals.

We could take the example of fossil fuels being subsidised very heavily in some countries. Iran and China alone subsidised oil consumption to the tune of 60 billion dollars in 2007 (International Energy Agency 2008). This may have been a good incentive to boost local industry, but from a climate change abatement viewpoint this incentive effect is totally different.

Another example of imperfect government policy from the environment viewpoint is the former economies of Eastern Europe, where the banishing of short-sighted profit motive was hailed as an opportunity to implement policies truly generated to maximising welfare. However, the policies achieved the exact opposite effect, partly because of a simplistic appliance of Marxist theory where value is only created by

[19] Economies of scale: The increase in efficiency of production as the number of goods being produced increases.

labour. By treating natural resources as free goods of no value, the intrinsic value of those resources was, in quite a few cases, effectively destroyed. The Aral Sea is a sad symbol of such policy. The gigantic inland sea has been turned into “a poisonous dust bowl” as a result of irrigation projects, defective management, and excessive cotton production (Sterner 2003).

One possible and quite plausible explanation for the frequency of bad policy is lack of information or understanding about the technical, ecological, and economic relationships that are used to pick and design policy instruments (Sterner 2003). Other explanations stem from the fact that policies are not in all cases designed by altruistic welfare-maximising policymakers. It would be naïve to think that they would be free from personal economic or political interest. Furthermore, institutions are not perfect, and it would be hard to say that the government or any other institution would be neutral and the perfect agency to enforce the general wellbeing of society (Sterner 2003).

Still, it is crucial that governments try to correct market failures by using policy instruments. It is highly important that the private sector as well as civil society brings out policy failures and helps governments to pinpoint and correct them.

3.7 International Aspects of Climate Policy and Renewable Energy Generation

We are living in the middle of a strong globalisation trend. Investment and businesses among others move beyond domestic and national markets to other markets around the globe, thus increasing the interconnectedness of different markets. Global trade has increased efficiency[20], but at the same time it has made care of the environment a highly

[20] From a comparative advantage view point a country has a comparative advantage in an activity if the country can perform the activity at a lower opportunity cost than any other country. Hence the theory suggests that countries should specialize in the goods they can produce most efficiently, rather than trying for self-sufficiency, and argues strongly in favour of free international trade (Ricardo 1817, Porter, van der Linde 1995).

complex issue. It has also increased international interdependency, which is especially highlighted in energy issues, but has not always been seen as a positive phenomenon.

3.7.1 International Climate Policy Formulation

Global warming is a global public good or commodity. Its impacts are indivisible and its impact is felt all around the world, rather than affecting only one nation or town (Nordhaus 2007b). Equally, carbon dioxide (CO2) is a global pollutant. A ton of emissions from any point on the globe at any given time would have the same effect on the atmospheric concentration of CO2 and thus cause the same amount of damage (Congressional Budget Office 2008). Hence it is only rational that international measures are needed.

The need for global decision-making leads to the “Westphalian sovereignty dilemma”. Under international laws as were developed in the 1648 Treaty of Westphalia and evolved thereafter in Western Europe, obligations may be imposed on a sovereign nation-state only with its own consent. Hence there is no legal mechanism by which countries could be coerced to provide for the global public goods. The Westphalian system is therefore one that allows free-riding. We must therefore take an entirely different approach to global public goods compared with those taken for regional, national or local public goods.

Because international treaties must be negotiated under the restrictions of sovereignty, the structure and design of environmental and other treaties are usually analysed with recourse to game theory[21]. There is a strong element of “prisoner’s dilemma”[22] in the

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[21] Game theory: attempts to mathematically capture behavior in strategic situations, in which an individual's success in making choices depends on the choices of others (Sterner 2003, Hanley, Folmer 1998, Finus 2001).

[22] One example of the Prisoner’s Dilemma: Two prisoners jointly charged with a crime are held apart, and each is given the option of confessing, or of not confessing. If each confesses, the prosecutor/judge convicts them both, and they will serve six years each. If neither confesses, the prosecutor will find a lesser charge, and each will serve two years. (Continues next page)

structures of the games, because although countries jointly benefit from collaboration, there are also incentives to free-ride. National sovereignty (Sterner 2003) means that treaties must be written so that compliance is in the interest of each nation, because there is no possibility for enforcement.

However, because the games are repeated, countries have an interest in building good reputations and relations, which facilitates the achievement of collaborative equilibrium (Sterner 2003). Trigger strategies may be used, and there may be various opportunities for retaliation as nations "play" many different "games", which may be interconnected (Hanley, Folmer 1998). For example, one country might react to unfavourable regulations in climate policy by retaliating in another field, such as trade (Sterner 2003).

The coordination between international treaties and regional as well as domestic policies is often complicated. Environmentalists often wish to be proactive and suggest that their own countries set a good example, and to show that certain goals or technologies are feasible (Sterner 2003). These people most likely believe in the Porter hypothesis[23]. However, altruistic emission reduction in one country may easily be undone by increasing production and emission in a competing country (Sterner 2003).

If an international but not fully global climate policy results in differences in marginal compliance cost among countries, then emissions may leak from participating high-cost countries to non-participating low-cost countries through one of two economic channels (Aldy, Barrett et al. 2003). Firstly, a policy by participating countries may shift

If A confesses and B does not, A is released and B serves an aggravated ten years. If B confesses and A does not, B is released, and A serves an aggravated ten years. The surprising truth about the game is that whatever the other prisoner does, a prisoner does better by not confessing. The dilemma is easy to generalise for example in relation to an emissions treaty and the positive side of cheating in it.

[23] Porter's hypothesis: environmental regulation will increase productivity as a result of its implicit effects on innovation, mostly because cleaner technologies have not previously been explored and generally turn out to be more efficient and hence lead to cost savings. The effort of having to adapt to strong regulation forces a company to increase its productivity, which gives the firm a strong position vis-à-vis competitors (Porter, van der Linde 1995) (Sterner 2003).

comparative advantage in carbon-intensive goods toward non-participating countries, and therefore the production of such goods, and the emissions, may grow outside the participating countries. Secondly, a policy may lower world demand for carbon-intensive fuels, and may thereby reduce the world price for such fuels traded in international markets. As a result, demand for such fuels as well as emissions can rise outside of the coalition (Stavins 1997). Hence a "narrow-but-deep" agreement may not significantly reduce net emissions, but may largely redistribute them instead (Aldy, Barrett et al. 2003). Estimates of the magnitude of emissions leakage vary widely (Aldy, Barrett et al. 2003). In the case of a unilateral reduction in emissions by the European Union, estimated leakage rates range from 2 to 80 per cent (Fisher, Barrett et al. 1996). This among other things might indicate that a global treaty would be highly important to be able to have radical results in cutting greenhouse gas emissions.

3.7.2 **Renewable Energy Generation Policy**

One of the most important individual factors affecting renewable energy generation's expansive market penetration and competitiveness is the international non-renewable energy price (mainly: coal, gas, & oil). As seen from Figure 8, oil prices have been rising during the past few years, though now partly as a result of global recession they have fallen dramatically. The IEA has predicted that in the long run this price might settle to be close to $60/barrel[24] (Valtioneuvosto 2008). This price, and especially the present figure of $42.00/barrel, from sixteenth of December 2008 (U.S. Energy Information Administration 2008), might not be enough on its own to excite new fast-track investment in renewable energy generation (Valtioneuvosto 2008). This seems likely, because there was no huge rush towards new renewable energy generation even when the oil price was close to $150/ barrel and some were even speculating it would climb to over $ 200/barrel in the near future (Fortson 2008).

[24] EUR/USD = 1.3617 → EUR 0.02 = USD 0.0147 (8.1.2009) (Bank of Finland 2009).

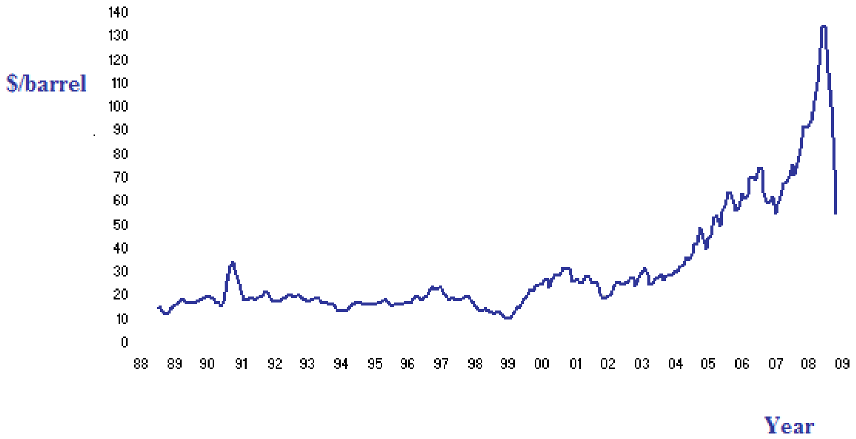

Figure 8: Brent Crude Oil Closing Price ($/barrel) Average Monthly Data from 1988 to 2008[25]

Energy is a mainstay of an industrial society (Kreith, Goswami 2007). Most governments have sought to keep energy policy as a domestic responsibility, intervening either directly or through national firms to maintain some degree of sovereignty. Energy is regarded by many as being too crucial to leave to international market forces (McGowan 1996). Nonetheless, the average energy independence of European Union (EU-15)[26] member-states has been around 50 per cent during the last decade, and it has been expected to rise without intervention. This fact has to a greater or lesser extent increased EU interest in boosting renewable energy generation in the name of energy security. Interest has mainly varied depending on the international situation. The energy crises during the 1970s speeded up the concern to a peak. In addition, recent crises with Russian gas delivery cuts have given similar incentives to the EU (CIVITAS 2008).

Since the structural changes in energy generation towards local renewable energy generation have not taken place with the current conventional energy prices, change - if desired - might have to be widely subsidised. On the other hand, if the external costs of non-renewable energy would be internalized as well as market barriers hindered, this

[25] Based on data from (U.S. Energy Information Administration 2008).

[26] EU-15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom

might be enough at least to accelerate the change towards a higher share of renewable energy generation (IEA 2003). Nevertheless, policy instruments are needed in this case as well.

3.8 Optimal Policy Instrument

The sub-chapters above have scrutinized the reasons why we need local as well as global policy intervention, focused on climate policy and renewable energy generation policy. Now that we have justified the intervention, the next step is to choose the best possible policy instrument. Nonetheless, before we start to scrutinize real policy instruments (presented in Chapter 6), as a good baseline we should first examine how the optimal policy instrument would work.

In the climate policy case, the optimal policy instrument is in theory found by pinpointing the marginal abatement cost of emission and the marginal damage cost of emission and resolving their intersection point. This is exemplified in Figure 9 below.

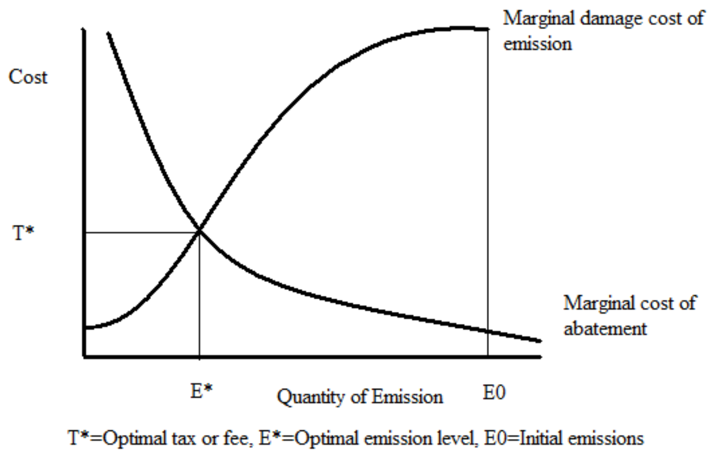

Figure 9: Optimal Tax or Fee (Pigovian Tax)[27] [28]

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[27] The figure strongly imitates one presented in (Sterner 2003). Curves are hypothetical and their structure could be totally different. Both variables are in reality subject to great uncertainty.

[28] Marginal cost is the change in total cost that arises when the quantity produced changes by one unit. Thus, here in the marginal damage cost of emission case this means total damage cost increase when we

To be able to forecast these curves we would need perfect knowledge of the market and the environment. In reality, these curves could look totally different[29]. Nevertheless, if we could somehow predict the curves, this intersection point would reveal two things: an optimal quantity-type policy instrument to cut back emission from initial emissions (E0) to an optimal level of emissions (E*) and a price-type policy. This would impose a fee or tax (T*) on polluters, and therefore motivate them to cut back emission to E* (Sterner 2003). This optimal tax that internalizes the externalities is called a Pigovian tax. If we set the tax too low, then we allow too much emissions and our welfare will suffer. On the contrary, if we set the tax too high, we perform too much abatement from the welfare maximization viewpoint and our welfare will suffer once again (Stern 2007).

If the tax provides an incentive to reduce emissions, one can also encourage certain behaviour patterns by subsidizing them. In this case, the optimal subsidy would be the same size as the Pigovian tax and for this reason it is sometimes called negative Pigovian tax (Sterner 2003). The motivation for such a subsidy is to try to reach economic efficiency. When a positive externality is present in the form of new technology knowhow, energy security, or energy generation reliability, a company's solution of its utility maximization problem does take account of the additional utility produced as a by-product, which causes wealth to others. This causes the company to invest less than the Pareto-efficient level (Jaffe, Newell et al. 2005). The Pigovian subsidy thus “pays” the positive externality to the company, thereby giving the company an incentive to invest more than it otherwise would.

While the real world optimal policy instrument(s) or level of intervention with climate policy, energy generation policy, and other issues remain unresolved (and probably will be so forever), empirical experiences show that economies with an extensive degree of intervention fail gravely in attaining efficiency. On the other hand, economies with a highly free and unregulated market may also fail conspicuously with both efficiency and

pollute with one more ton of carbon dioxide. The marginal cost of abatement on the other hand here means the total abatement cost increase when we abate one more ton of carbon.

[29] Debate about the possible outlook of these curves is discussed in Chapter 4.

social issues (Sterner 2003). Therefore, in our imperfect world, the right solutions will probably be found somewhere in the middle.

4 Economics of Climate Change

Economics is the social science that surveys the choices that individuals, businesses, governments, and entire societies make as they cope with scarcity and the incentives that affect and reconcile those choices (Parkin, Powell et al. 2005). Because our resources are limited, we are not able to satisfy all our wants, and we have to make choices between multiple interests. The economics of climate change, if over-simplified, is the choice between two different variables and their weights: damage adaptation and the abatement of climate change, as shown in Figure 10 below.

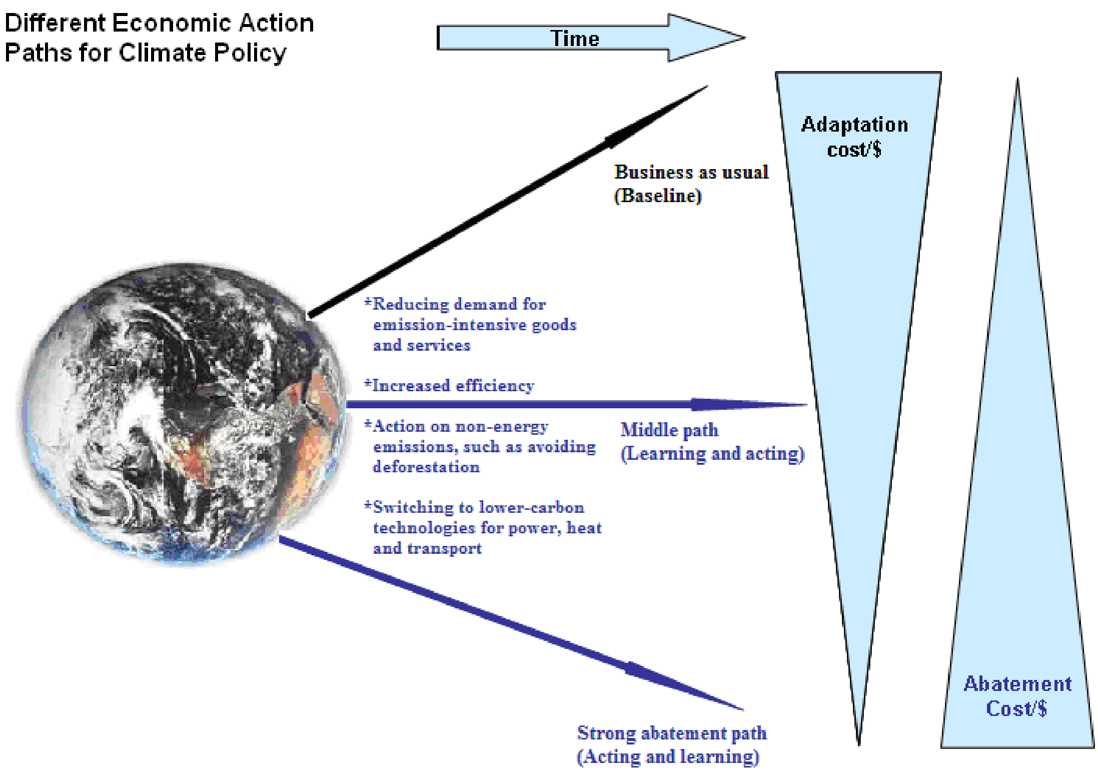

Figure 10: Economics of Climate Change: Baseline versus Strong Greenhouse Gas Abatement

From this viewpoint we can select either to take strong action against climate change in advance in the form of greenhouse gas abatement, and thus most likely cut our damage adaptation costs, or then we can save in abatement and put the money to use in damage adaptation or something else. The business as usual (BAU), in other words the baseline, is the emission growth path or trajectory that would happen if we continue without radical change in emission intervention. The business as usual or even negative results for abatement (less abatement than in BAU) do not imply doing nothing, but rather point out that investing in damage adaptation is stressed (Pearce 2002). On the other hand, choosing the strong abatement path implies that we simply want to avoid possible large damage adaptation expenditure. With other things being equal, we should end up choosing the path that leaves us with a smaller triangle (smaller cost).

Still, as the IPCC synthesis report (IPCC 2007b) points out, there is high confidence that neither adaptation nor abatement alone can avoid all climate change impacts. Adaptation is necessary both in the short term and longer term to address impacts resulting from the warming that would occur even for the lowest stabilisation scenarios assessed. This would suggest that we should choose the smallest summarized area of both triangles to cope with.

The challenge is that the size of these triangles is very hard to estimate. The difficulties of expressing non-market impacts like human health or effects on ecosystems in money, the long life of greenhouse gases, possible catastrophic damages, and generational and sustainable development aspects, as well as millions of other features all conspire to make this case even more complex.

Climate change affects many different agents on various different levels. For example ecologists may see it as a threat to ecosystems, ski resorts or coal-miners as a hazard to their livelihood, or small island states as a threat to their very existence. On the other hand, some northern farmers may see it as an extended agricultural opportunity, golfers as a possibility for year-round recreation, and renewable energy companies as a new business opportunity (Nordhaus 2008).

This really does not help with our quest to determine the optimal path and the size of the triangles in Figure 10. We can, however, try to estimate them, but in this task we encounter many dilemmas:

- Ethical, e.g. what to conserve?
- Liberty, e.g. to what degree must people be restricted from causing emissions?
- Efficiency, e.g. how much environmental damage is acceptable?
- Evaluation, e.g. how to compare different effects of various options or actions?
- Equity, e.g. who benefits from the mitigation, and who pays?

These are the dilemmas we have to cope with whenever we are thinking about policy intervention. However, the key dilemma and the keyword for climate change economics is uncertainty. How can we choose the best course of action without adequate knowledge or data about what will happen in the future?

Much research has highlighted the fact that "repairing" or "curing" ecosystems is normally much more expensive than prevention, and in certain cases the damage from emissions might be irreversible (Sterner 2003). On the other hand, over-investment and over-reaction might cause profound social welfare loss. Hence allocating resources unwisely and unfairly could cause in some cases irreversible social and economical losses (Nordhaus 2008, Pearce 2002).

However, economists recognize that although scientific understanding of the climate system is not complete and we have multiple dilemmas on the path to an optimal solution, it is appropriate to take measures now to address potential climate change. Economics can even provide guidance on how to deal with these uncertainties. Economic reasoning and evidence can help delineate the scope of the climate change problem, and can point the way to a rational societal response (DeCanio 1997).

Economic estimation of the climate change case is done by trying to figure out the three important variables that were already introduced in Figure 10:

- The baseline (Business as usual),
- The (marginal) damage cost of emissions
- The (marginal) abatement cost of emissions

The baseline is important, in order to be able to have a relevant frame of reference for damage costs as well as for abatement actions. Hence in order to estimate the impacts and success[30] of possible interventions, it is necessary to estimate what would have happened in the absence of the intervention. And because such counterfactual baselines cannot be observed, they have to be estimated.

The marginal abatement and damage cost are crucial for us to be able to estimate the optimal price (the social cost of emissions) and the target level of emission. This is the intersection of these two variables, as sketched in Figure 11 as well as in Chapter 3 (Figure 9). This is the same as optimizing the triangles in Figure 10.

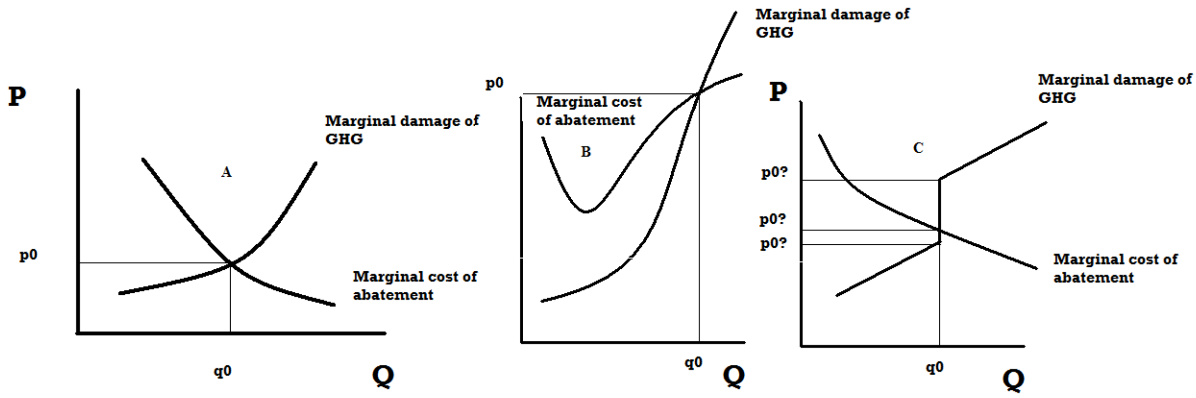

Figure 11: The Uncertainty in the Optimal Level of Abatement[31]

The curves in Figure 11 are not based on real estimations, but they describe the current estimation debate. Some researchers believe that the variables are smooth, while others have suggested that there might be threshold values as portrayed in diagram C on the right. Because of the great uncertainty of future damage as well as with the adaptation

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[30] The Helsinki Protocol, for example, required that parties reduce their sulphur dioxide emissions by 30 percent (Aldy, Barrett et al. 2003). This might suggest that agreement succeeded environmentally, but the agreement did not significantly affect behaviour (Barrett 2005). In the absence of the treaty, most of the emission reductions would probably have occurred anyway (Aldy, Barrett et al. 2003).

[31] p: optimal price for emission, q: optimal amount of emission, (see Chapter 2, Figure 9).

cost, different studies and models[32] give very different results of the optimal intervention level. At the same time, the values that different models give are affected primarily by the starting values. However, different models have special characteristics that affect the output value; for example Tol (Tol 2005) gathered 103 estimates of the marginal damage cost of carbon dioxide from 28 published studies. All studies combined, the mode was \$0.54/t CO2[33], the median \$3.8/t CO2, the mean \$25.3/t CO2, and the 95 percentile \$95.4/t CO2. The highest estimation was as high as \$1666.7/t CO2 introduced by (Hohmeyer, Gartner 1992, Tol 2005). Because of the great variance, it is evident that essential questions still remain unresolved and the reasons for this great variance need closer examination.

4.1 The Academic Debate on the Economics of Climate Change

In Table 4 below, the authors and the studies that are stressed in this chapter are presented, as well as a summary of the main focus and results of the articles. These studies were selected to get a good overall view of the economics of climate change as well as to map the current field of debate. With the help of these studies it is also easy to spot the research that might offer more in-depth knowledge about some special issues like the science of uncertainty.

Table 4: Selected Appraised Authors Their Main Focus and Results. (Continues next page)

Author	Main Focus	Main Result
(Gore 2007)	How to respond to climate change	US should join an international treaty within the next two years that cuts developed countries' GHG emissions by 90% and more than 50 % worldwide in reasonable short run.
(Nordhaus 2008)	Modelling the economics of climate change	Climate change is a complex phenomenon, subject to huge uncertainty. It has to be taken seriously, though too fast and too furious acts in the short run might do more harm than good.

[32] For more information about different models see (Nordhaus 2007a, Sterner, Persson 2007).

[33] Scientists and economists have usually measured carbon prices in terms of carbon weight. In this thesis on the contrary I use carbon prices in terms of carbon dioxide weight, as is used in the EU emission trading scheme. Carbon dioxide has a mass 3.67 times that of carbon. To convert from the CO2 units to the units of carbon, divide the mass or multiply the price by 3.67.

(Nordhaus 2007a)	Critical review of the Stern review on the economics of climate change	Article professes that the main argument of Stern review (2007) that we need urgent, sharp, and immediate reductions in GHG emission is based on vague research. Nordhaus argues that discount rates and consumption elasticities that were used were not realistic and should be substituted with ones that are more consistent with today's marketplace real interest rates and savings rates. He prefers "climate-policy ramp", in which policies to slow down global warming increasingly tighten over time and fulfil where and when efficiency.
(Pearce 2002)	The social cost of climate change	It is possible to estimate the aggregate and marginal cost of greenhouse gas emissions. These estimations should be used when appraising climate change policy, especially to see whether too much or too little abatement is being considered. Equity weighting and discounting have a strong effect on to the marginal social cost of carbon. These should be wisely selected and if used they should be equally applied across all policies like aid and trade because it is not defensible to argue that global warming is a "special case" compared with these. Some models give negative results for climate policy. These results do not imply "doing nothing" but rather stress a reappraisal of the balance between investing in emission reduction and investing in adaptation, especially in developing countries.
(Stern 2007)	The economics of climate change	Climate change is the greatest and widest-ranging market failure ever seen. Strong action to reduce GHG emission should be undertaken right away, as the benefits of strong, early action considerably outweigh the costs.
(Sterner, Persson 2007)	Critical review of the Stern review on the economics of climate change and its critics	Review defends results of Stern review (2007) and sheds light on discounting methods that have been under criticism. Furthermore, authors are concerned that Stern review might not give sufficient weight to non-market damage, and changing relative prices are not analysed by Stern report, both which might make the damage cost even higher. Taking these variables into account, damage optimal emission paths would be even more radical than Stern review reported, even though discount rates would be set as high as market-based trajectories yield.
(Tol 2005)	The marginal damage costs of carbon dioxide emissions	It is possible to estimate magnitude of marginal damage cost (MC) of carbon dioxide emissions. Review analyses 103 estimates of the MC gathered from 28 published studies. The best guess for MC of carbon dioxide emissions is $5/tC (1.4$/tCO2), but the mean is $104/tC (28$/tC02). Two "ethical" parameters have high impact on estimate differences as well as on uncertainty. These are equity weighting and especially discounting. As a conclusion, the author estimates that even though climate change impacts may be very uncertain, it is very unlikely that the MC of carbon dioxide emissions exceeds $50/tC(14 $/tCO2).
(Weitzman 2007)	Critical review of the Stern review on the economics of climate change	The review gives credit to the Stern review for appraising the level of public disclosure by increasing general awareness of the gravity of climate change. Weitzman argues that even though from some perspective the discount rate that Stern used can be approved, it is not a mainstream economist view and thus should not be presented as if it were. He shares Stern's view that the implications of large consequences with small probabilities are important. Hence gathering information about uncertainties representing rare climate disasters and developing a realistic emergency plan were they to materialize should be a priority of research. Weitzman sees that the review's informal emphasis on climate-change uncertainty could be recast into sound analytical arguments that might justify some of its conclusions. However, spending money now to slow global warming should not be stressed primarily as being about optimal consumption smoothing as Stern sees it, but as an issue of how much insurance to buy to offset the small chance of a ruinous catastrophe that is difficult to compensate by ordinary savings.

Although there has been research into the economic effects of climate change for decades now and the Intergovernmental Panel on Climate Change (IPCC) has been functioning for 20 years, the economic research debate rose to a new level two years ago after Stern published his famous review (Stern 2007). It gave a more general face to the economics of climate change and to the possible effects on the economy. The reason may have been that it offered such high estimated damages from climate change relative to earlier studies and models that it was not easy to overlook without a mention. Earlier studies and Stern critics have estimated the cost of climate change impacts on the order of one per cent of the future Gross Domestic Product (GDP) (Sterner, Persson 2007). Stern (2007) asserts by contrast that the business as usual (BAU) emissions of greenhouse gases will lead to a minimum damage of 5 per cent of GDP and might be as high as 20 per cent of GDP now and forever (Stern 2007).

This result stimulated widespread debate. The big picture of the debate is how radical are the actions we should take immediately on climate change abatement. Stern's (2007) conclusions suggest that strong collective action should start right now. We should invest about 1 per cent of GDP in abatement each year. Stern (Stern 2007) estimated that the benefits of strong, early action on climate change outweigh the cost. On the other hand, the major findings of earlier studies and models have been that an efficient optimal path would involve modest rates of emission abatement in the near term, followed by sharp reductions in the medium and long term. This is also called a climate-policy ramp, in which actions to slow down global warming increasingly ramp up over time, when for example the technology develops (Nordhaus 2007a).

The reason for this great difference between opinions as to what kind of strategy to use derives from the fact that Stern (2007) sees that the marginal damage cost and marginal abatement intersection point is at the present a factor of ten higher ($85/t C02, year 2005) than that which Nordhaus (Nordhaus 2008) among others has estimated ($7.4/t CO2, year 2005). Minor criticism of the Stern review is concentrated on the point that Stern has over-estimated the cost of adaptation and underestimated the cost of abatement (Honkatukia 2006).

While the estimation of our three main variables the baseline, marginal abatement cost of emissions and the marginal damage cost of emissions is seen as a complex task, owing to the uncertainty, the most debated factor affecting these estimations, i.e. the discount rate[34], is a relatively simple concept in economics. The main criticism of the Stern review has not focused on its assessment of the cost and benefits of climate change abatement or the climate science embodied in the report, but rather on the low discount rate used in the analysis (Sterner, Persson 2007).

4.1.1 **The Discount Rate**

The discount rate does indeed cut to the core of the fundamental questions regarding global environmental change: how much weight we should put on the welfare of future versus current generations? Will growth continue so that future generations are really richer than we are today? How important is the distribution of impacts? That is, how should we value costs that fall disproportionately upon the poor or the rich? (Sterner, Persson 2007)

The rate at which we discount the future will have a huge impact on the extent to which emissions reductions today are warranted economically (Sterner, Persson 2007). Using a discount rate of 1 per cent, in 300 years the discounted value of $1,000,000 would be close to $50,000. If the discount rate were 5 per cent, the discounted value of $1,000,000 would be less than 50 cents (0.44 cents) (Sterner, Persson 2007).

While some researchers stress that we should discount the climate change damage with values close to the market rates (Nordhaus 2008, Tol 2005, Weitzman 2007), others stress that in the case of environmental issues the discount rates should be lower (Stern 2007, Sterner, Persson 2007, Cline 1992). In fact it is not an exaggeration to say that the biggest uncertainty of all in the economics of climate change is the uncertainty about which interest rate to use for discounting (Weitzman 2007).

[34] See definitions: discounting

Despite the controversy, most participants in the debate about what constitutes an appropriate discount rate for estimating climate change damages acknowledge that a good starting point is the Ramsey rule[35].

$$r = \delta + g \times \eta \qquad (2)$$

The Ramsey rule holds that the discount rate should be set equal to the sum of two factors: the pure rate of time preference, δ, and the product of the growth rate of income, g, and the elasticity of the marginal utility of money (also, equivalently, the coefficient of relative risk aversion and equity weighting), η. The first component, δ, implies discounting of future utility per se, while the second implies discounting the value of future consumption goods based on the notion that we will be richer in the future and that the rich gain less welfare than the poor from a given quantity of money (Nordhaus 2007a, Sterner, Persson 2007). Table 5 shows Ramsey equation variables used by Stern and two of his critics.

Table 5: The Ramsey Equation Variable Used by (Stern 2007), (Nordhaus 2007a), *and* (Weitzman 2007).

Author	**The pure rate of time preference (δ)**	**The growth rate of income (g)**	**The elasticity of marginal utility of money (η)**	**Discount rate (r)**
(Stern 2007)	0.1%	1.3%	1	1.4%
(Nordhaus 2007a)	1.5%	2%	2	5.5%
(Weitzman 2007)	2% (inter alia)	2%(inter alia)	2(inter alia)	6%(inter alia)

4.1.2 The Pure Rate of Time Preference (δ)

In using a value of 0.1 with the pure rate of time preference (δ) Stern takes a very egalitarian view of intergenerational distribution. This view is also favoured by (Sterner, Persson 2007, Ramsey 1928, Dasgupta 2006). Weitzman (2007) and Nordhaus (2007a) among others argue that the Stern principle of treating all generations equally takes no

[35] For more in-depth information see (Ramsey 1928).

account of preferences for present over future utility, which people seem to exhibit in their everyday savings and investment behaviour. They thus suggest that higher values be used. As a response, Sterner and Persson (2007) highlights that the 0.1 per cent pure rate of time preference is compatible with the risk of extinction of humanity of about 10 per cent per century, or 65 per cent per millennium.

4.1.3 **The Growth Rate of Income (g)**

For the growth rate of income (g) Stern (2007) uses 1.3 per cent. Thus in Stern's case, per capita consumption is projected to grow from \$7,600 today (2005) to \$94,000[36] in the year 2200. Here Sterner and Persson (2007) raises the question "*can growth go on for so long?*" In certain fields of industry like oil or cement, this kind of path might be hard to sustain, but in those areas that need insignificant physical resources this kind of growth might be feasible (Sterner, Persson 2007). Here the value for the growth rate of income (g) of 2 per cent preferred by Nordhaus (Nordhaus 2007a) would project the per capita consumption to \$361,000 in the year 2200.

Even though we have here highlighted Weitzman's (2007) example value of 2 per cent for the growth rate of income (g), he has also argued in his study that there is a possibility that g could even become negative because of possible catastrophic events and that this factor should be studied more precisely. This kind of viewpoint would partly back up Stern's (Stern 2007) results that more relevant action should be taken now. Nevertheless, compared to Stern (2007), Weitzman (2007) stresses that spending money now to slow global warming should not be seen primarily as being optimal consumption smoothing, as Stern sees it, but rather an issue of how much insurance to buy to offset the small chance of a ruinous catastrophe that is difficult to compensate by ordinary savings.

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[36] Here we have used a formula for future discount that is: Future value = (1+ discount rate)^number of years between present and future point of time → \$94,331 = (1+0,013)^195

4.1.4 The Elasticity of the Marginal Utility of Money (η)

The elasticity of the marginal utility of money (η) is also known as the coefficient of relative risk aversion and equity weight variable. Equity weighting has been one of the greatest issues in the climate change abatement debate, because the biggest effects of climate change are felt in poor countries and they have least money for the adaptation.

The higher the value of the elasticity of marginal utility of money (η), the less we care for a dollar more of consumption, and the richer we become. If we expect that we will be richer in the future, when climate damages will be felt, a higher value of the elasticity of the marginal utility of money (η) implies that damages will be valued lower. Hence it implies less greenhouse abatement today. Conversely, in the case that we will be poorer in the future, a higher elasticity of the marginal utility of money (η) would imply that more abatement would be warranted (Sterner, Persson 2007).

The idea that a rich person would have less marginal utility for money than a poor person is deeply rooted in economic theory and is empirically well-founded. Nonetheless, the magnitude of the effect it would have is still controversial (Pearce 2002, Sterner, Persson 2007). The practical implications of this are actually quite radical: already the elasticity of marginal utility of money value - $\eta=1$ - that Stern (2007) has used means utility is logarithmic (Sterner, Persson 2007). If we assume that person R is 10 times richer than person P, then taking $1.00 from R and giving it to P would increase P's utility 10 times more than the loss of utility to R. This could well be the case when comparing developed and developing countries. However, with a η of two as is used by Nordhaus (2007a), P's utility would be 100 times more (Sterner, Persson 2007).

Thus, when η is large, then the aggregate welfare would be much higher in an economy with an even income distribution, and it would suggest that high and progressive taxes as well as large transfers of development assistance to poor countries should be implemented (Sterner, Persson 2007). This income distribution has been the utopia in both foreign aid and in trade protection, where we have used an η value close to zero. Hence it is argued if higher values are used with climate change policy, they should be used with other policies as well (Pearce 2002). Pearce (2002) continues that, if so, then values from 0.5 to 1.2 seem reasonable for η. It follows that it is somewhat strange that Stern critics have criticised the η value of 1 that Stern has used, claiming that it is too low, when in other contexts economists have used a η value of zero (Sterner, Persson 2007).

If we use the discount rate to lower the estimates of the costs that our descendants will face, leaning on the argument that they will be so much richer and the utility function is so curved, we should logically give extra weight to any low-income people affected (Sterner, Persson 2007). This is noticed and also integrated into many of the cost estimation models. As the Tol (Tol 2005) and Pearce (2002) studies show, if equity weights are used, other things being equal, it may increase the damage cost estimations from 20 to 70 per cent, though the effect is not as radical as when the discount rate is changed.

Thus, by taking a different perspective to our dilemmas, we can make huge changes to our estimations by a using different discount rate or equity weighting. Even though here we have used Stern as one extreme and some of his critics as another, there are also views that the Stern's values are too low and that an even more radical intervention would be needed. Sterner and Persson (2007) for example point out that because of Stern's underestimation of the relative prices,[37] even stronger intervention may be needed. In addition, even Stern himself has implied in June 2008 that because global warming is happening faster than predicted, the cost to reduce carbon would be even sharper or about 2% of GDP instead of the 1% in the original report (Jowit, Wintour 2008).

[37] Sterner and Persson (2007) points out that Stern (2007) might have underestimated the relative prices of fossil fuels as well as especially non-market resources in his estimations. Water, biodiversity, or other essential ecosystem services are hard to replace, and consequently their price elasticity might be much lower than the 1 that is conventionally used for income or -0.65 for fossil fuel. Were these resources to become scarcer, their relative price might rise very fast. For example, currently global agriculture is said to represent 24 per cent of global GDP (Stern 2007). Hence a 10 per cent loss might be approximated as costing 2.4 per cent of the global GDP. Everyday logic, however, tells us that a 50 per cent loss would be worth much more than 12 per cent of the global GDP, and a 100 per cent loss would be worth more than 24 per cent of the GDP. As food became more and more scarce, its relative price would rise so fast that the dwindling food supplies would crowd out everything else and would approach 100 per cent of the total GDP (Sterner, Persson 2007).

Even if there are radical differences between the views of Stern and those of his critics, there is also a high degree of unanimity that climate change is a grave phenomenon that needs to be taken seriously. Weitzman for example, one of Stern's critics, has stated that Stern might be right but for the wrong reasons, but that he has nevertheless done a good job in heightening the level of public awareness by increasing general awareness of the seriousness of climate change (Weitzman 2007). The majority of the critics see that it would be important to set a global price for the carbon dioxide emissions, invest much more in environment-friendly technology, and remove barriers of behavioural change (Nordhaus 2007a, Sterner 2003, Stern 2007, Weitzman 2007). They merely have quite different weights and time-scales for these remedies.

Now that economists have opened up the debate and discussed the major questions, the next step is for the policy-makers to decide what kind of emphasis they prefer and consequently how strong actions they will take. Thereafter, when the politicians and others are deciding which kinds of instruments to use, economists will once again have much to say regarding the effectiveness and efficiency of the various instruments (McGowan 1996), as will be discussed in Chapters 6 and 7.

5 Different Policy Instruments for Climate Politics and Renewable Energy Generation

This chapter describes briefly the operational principles of different climate and energy policy instruments. Only the standard models of different instruments are highlighted. In reality, the policies are most often adjusted with different additional features and they are used as a portfolio together. They may in practice overlap with each other as well as with other policies, thus causing indirect effects for each other.

This is not the first study ever made on renewable energy policy instruments for the Finnish Energy Industries. A Masters' thesis (Arasto 2006) and a report (Green Stream Network 2007) predating this study have been taken into consideration. Arasto's (2006) thesis generally presents the operational principles of energy policy instruments among others from economic perspectives, stressing the investor's point of view in economic support schemes. The Green Stream Network report (2007) then again investigates implementation perspectives, for which they have gathered a large amount of empirical data to back up their research. Hence to avoid unnecessary overlapping, in this chapter a lot of the emphasis is on the climate policy instruments. Instruments for renewable energy generation have been presented more briefly. The reader may wish to consult (Arasto 2006), (Green Stream Network 2007), or (Sawin 2004) to be able to get a deeper understanding of the principles of how renewable energy generation policy instruments function, and what kind of applications have been used.

Before examining different instruments more closely, we should try - for the sake of simplicity - to categorise the instruments, in order for us to be able to perceive them better. Many policy matrices have been proposed as organising principles for the systematic comparison and collection of policy instruments (Sterner 2003). One much-used typology is the World Bank (World Bank 1997) model, grouping policy instruments into four categories: (1) using markets, (2) creating markets, (3) implementing regulations, and (4) engaging the public. On the other hand, some political scientists argue that there are only three basic categories for policy instruments: "*sticks, carrots, and sermons*", symbolising regulation instruments, economic incentives, and informative instruments (Bemelmans-Videc, Rist et al. 2003). No single taxonomy is necessary preferable, but each can be used in different contexts (Sterner 2003).

Even though policy instruments for climate policy and renewable energy generation are introduced together in this chapter, we have to remember that they can have different as well as similar targets. While the main target of climate policy instruments is to curb greenhouse gas emissions, the main target of renewable energy generation instruments is to enhance renewable energy generation. This is done for various reasons: for the environment, for energy security, as well as for the substitution of fossil fuel energy generation with renewable energy generation as a cheap source of energy generation. Hence their categorisation together might give rise to some confusion.

However, policy instruments for climate policy and renewable energy generation have been organised into 5 categories as seen in Figure 12 below. In addition to the "stick, carrot, and sermon" categorisation, I have used research and development, other policies, and voluntary instruments alongside of them. Because instruments for climate policy and renewable energy generation have different targets, different colours have been used to point out the primary use-function of categories or sub-categories.

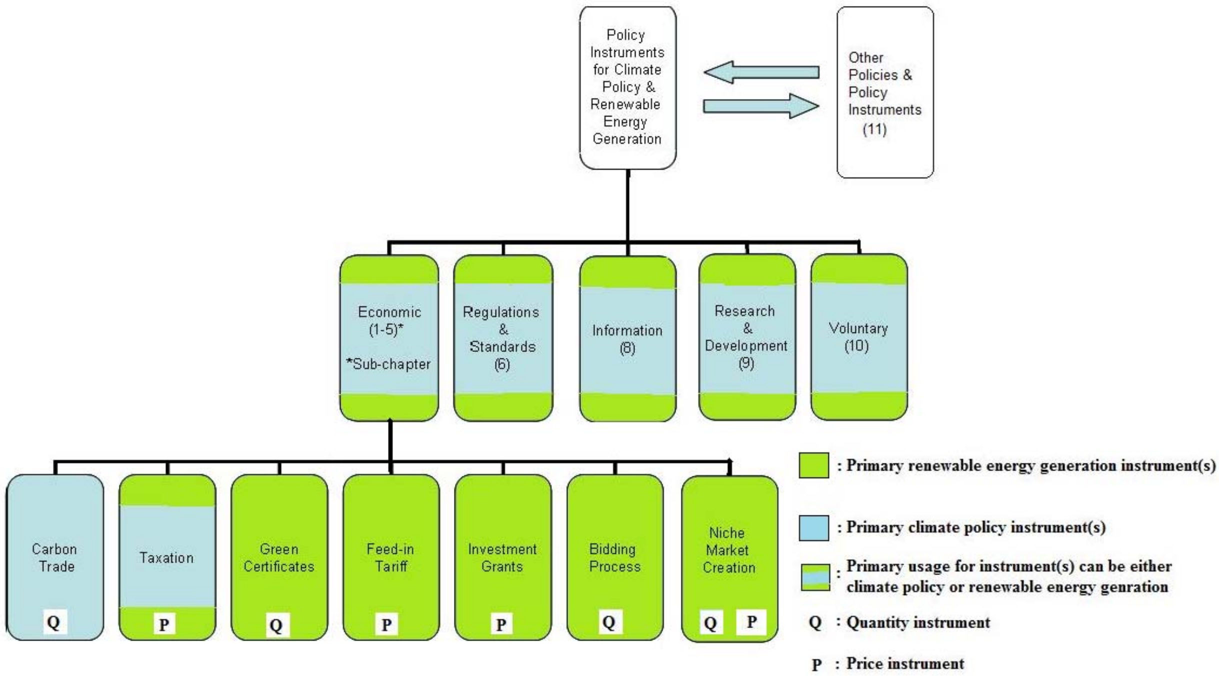

Figure 12: Policy Instruments Categorisation

Economic instruments have been further divided into 7 sub-groups. These are classified as either price or quantity categories. The choice of category to use is one of the main debates when choosing the policy instruments for climate policy or for renewable energy generation, as we will soon find out.

5.1 Emission Trade

The theoretical foundation of emission trade is Coasian (Coase 1960). Coase argued that markets could solve the pollution problems as effectively as taxes set by public administration, provided that rights were well enough specified. An emission permit, in other words an emission allowance, is a bounded and transferable right granted by central authority for an agent to emit a certain amount of emission into the environment. The emission trading refers to the trade that takes place with these emission permits between agents (Nykänen 2006).

The idea of emission trade is to execute the emission abatement actions where it is the most cost-efficient. In other words, where the marginal abatement cost is the lowest (Nykänen 2006). The key principle here is that agents are given allowances to emit absolute volumes over a fixed period. Agents that can cheaply abate their emissions to below the set limit may sell surplus emission allowances to others that are facing only more expensive options of reducing emissions. As a result, the total cost incurred by all parties in meeting the mandated reductions is below that of pure environmental regulation. In this way, this efficiency benefits society as a whole (International Energy Agency 2005).

The broad concept of emission trading is introduced in Figure 13 below. The emission trade covers "cap-and-trade" and "rate-based" regimes, and sometimes "project-based" mechanisms (International Energy Agency 2005). These are more closely introduced in Table 6, also below. The flex mechanism, allocation mechanism, and participation will be introduced and explained further on.

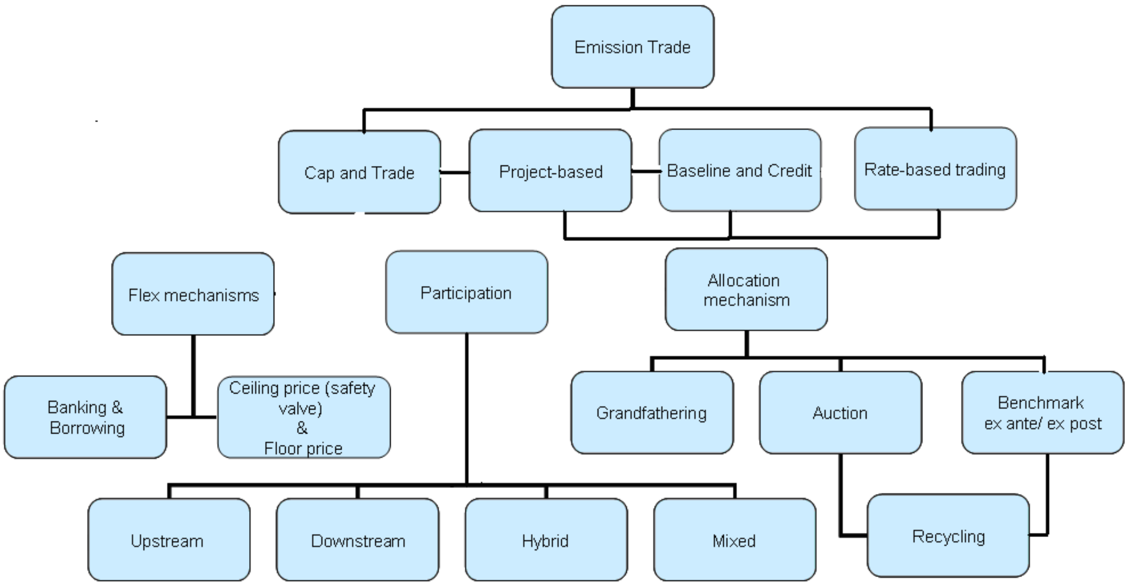

Figure 13: Structures of the Emission Trading Scheme

Table 6: Different Emission Trading Schemes (International Energy Agency 2005)

	Cap-and- trade	**Rate-based trading**	**Project-based trading**
Application	Applies to all emissions	Applies to emission relative to some defined standard (e.g. emissions per unit of output)	Applies to emission reductions below defined baseline
Allocation method	Allowances are allocated by the regulatory authority	Credits are generated when a source reduces its emissions below the norm	Credits are generated when a source reduces its emissions below an agreed baseline
Market dynamic	Participants (and possibly outsiders) can buy and sell allowances	Participants (and possibly outsiders) can buy and sell allowances	Project hosts sell to those participants obliged to purchase external reductions
Examples	Article 17 of the Kyoto Protocol, US SO2 allowances programme, European emission trading scheme	US phase-out of lead in gasoline	Clean development mechanism and joint implementation (Kyoto Protocol)

Aside from the "cap and trade" and "rate based" division, emission trade can be divided between cap and trade and "baseline and credit". Baseline and credit works similarly to project-based mechanisms in Table 6 (above), though it can be expanded to concern the entire market. It can also be adjusted to work either on a intensity basis similar to a rate-based regime, or on an amount basis similar to the cap and trade regime.

5.1.1 Participation

The quintessential question with emission trading is who is taking part. There are four main models: upstream, downstream, hybrid, and mixed models. In an upstream scheme, the producers, processors, and transporters of fossil fuels are regulated (Faure, Gupta et al. 2003). In a downstream scheme consumers of fossil fuels can trade emissions and in a hybrid scheme the large consumers of fossil fuels are directly regulated, while the remainder of fuel consumption is regulated through an upstream scheme. In a mixed scheme, large emitters are regulated through a emission trade system, while small emitters are regulated through some other instrument (Faure, Gupta et al. 2003).

The upstream scheme would virtually capture all fossil fuel use and carbon emission in a national economy. It would be easy to administer, owing to the relatively small number of companies that have to be monitored for compliance. On the other hand, the downstream scheme would offer greater competition and stimulate more robust trading. However, it is harder to administer, and is thus regarded as problematic (Tietenberg, Grubb et al. 1999).

5.1.2 Allowance Allocation

With cap and trade the important issue is how allowances are allocated. Allowances can be allocated for free on the basis of historic emissions (grandfathering). Alternatively they can be allocated according to a benchmark, or thirdly they can be auctioned. In the case of grandfathering, the actual emissions of producers in a certain period in the past are used as a basis for the allocation of allowances. One method of deriving the allocations is to apply a reduction factor to the historic emissions. The outcome of this method is that for example electricity producers have the choice to use the allowances for production, or to not produce and to instead sell the allowances. The value of the allowances represents an opportunity cost, which - at least theoretically - will be taken into account (Rathmann 2007). The EU emission trading scheme is one example of a system using grandfathering.

Allowances can also be allocated for free using a system based on benchmarking. A useful benchmark is for example the CO2-intensity of the electricity production (e.g. 350g CO2/kWh). Benchmarks can be specific for different techniques and/or fuels. In order to determine the amount of allocated allowances, the benchmark can for instance in the electricity generation case be multiplied by the expected electricity production before the related period commences (ex ante) or by the realised electricity production after the period has ended (ex post) (Rathmann 2007).

An ex ante allocation based on benchmarking has no real material differences relative to grandfathering, as long as the amount of allocated allowances is not altered. In the case of non-production, the allocated allowances can be sold and thus the value of all allowances needed for electricity production materialises as opportunity costs. An ex post allocation based on benchmarks reduces the opportunity cost to electricity producers substantially. This is due to the fact that in the case of non-production, no allowances can be sold because allocation is based on *actual production*. Only the difference between the benchmark and actual emissions - in other words the amount of allowances that can be sold or needs to be bought - materialises as an opportunity cost (Rathmann 2007).

Allowances can also be allocated by means of an auction. In the case of electricity generation this means that electricity producers buy allowances from the auctioneer, which is usually the state. The price and the amount of allocated allowances are then determined through an auction. In this case the value of all allowances needed for electricity production materialises as a cost to the producer. Opportunity costs for allowances no longer exist. (Rathmann 2007). Hence this form of allocation reduces distributional distortions that free allocation and accompanying windfall profits[38] may create. It is the purest embodiment of the "polluter pays" principle[39]. Auctioning would also raise considerable revenue, which could be used either as a source of revenue for the government, recycled back to the sources, or used to reduce other taxes on employment or investment (Tietenberg, Grubb et al. 1999).

From an international viewpoint, another important allocation issue is how allowances are allocated amongst countries. Höhne, Phyllipsen et al. (Höhne, Phyllipsen et al. 2005) has compared the effect of the choice of stabilisation goal against different allocation methodologies on the quota distribution for emissions reductions between countries. Here in particular the difference between the ability to pay of developed and developing countries plays an important role. More complication throws up other equity questions, such as who should be responsible to pay and who benefits the most from emission mitigation (Aldy, Barrett et al. 2003). These will be some of the biggest stumbling-blocks in the path of international agreement.

5.1.3 **Flex Mechanisms**

Compared to say "command and control", emission trade itself is a flex mechanism. Emission trade can, however, be made even more flexible by additional flex features or by integrating different emission trade mechanisms. In the case of the Kyoto Protocol, there were three flex mechanisms: cap and trade, clean development mechanism

[38] Windfall profits are unexpected earnings not due to the efforts and expenditures of the entity that benefits, but due to the indirect affects of for example some policy instrument. With the EU emissions trading scheme, the term windfall profit is used to describe the price increase of all electricity sold to the market (Kara, Syri et al. 2008), thus generating extra profits for those who are not affected by the cost of emission trade, like for example hydropower generation. However, in terminology windfall profit means sudden unexpected profit and thus it is highly arguable that emission trading scheme effect on electricity price is not windfall profit but normal economical causalities.

[39] The principle that the party responsible for producing pollution should also be responsible for paying for the damage done to the natural environment.

(CDM), and joint implementation (JI) (UNFCCC 2008b) (UNFCCC 2008a). Additional flexibility features that could be used are banking, borrowing, ceiling price (also known as "safety valve"), and floor prices.

The JI mechanism allows countries to cooperate on projects and transfer emission allowances on the basis of them. Furthermore, the CDM allows countries to finance projects in developing countries in exchange for credits towards meeting their own emission reduction targets (Aldy, Barrett et al. 2003). In effect, these add flexibility to meeting cap and trade targets.

The banking of allowances offers a greater degree of intertemporal flexibility, a flexibility that tends to reduce costs considerably. The banking of allowances involves allowing parties to carry forward allowances that are unused in one commitment period, in order that they can be used in the next period. There has been heavy use of banking in both the acid rain programme and the lead credit trading market in the United States. Banking is especially significant for industries in which major capital expenditures must be made. It allows individual agents flexibility in the timing of such major investments. Borrowing, then again, involves using allowances assigned for one commitment period in an earlier commitment period (Tietenberg, Grubb et al. 1999).

The "ceiling price", typically referred to as a "safety valve", is an optional design element of a cap-and-trade programme that seeks to provide cost containment by triggering certain actions if costs turn out to be higher than expected. One form of a safety valve is a price ceiling, which makes allowances available at some threshold price to ensure that the allowance price does not rise above a certain level and thus cause an excessive burden for emitters (Congressional Budget Office 2008). When safety valve or price ceiling is used, the instrument is often called a hybrid instrument. This is because it is no longer a pure quota-based instrument. It is a mixture of quota and price-based instrument.

As well as a price ceiling, a price floor could be maintained by selling a significant fraction of allowances in an auction and specifying a reserve price (Tietenberg, Grubb et al. 1999). This might help to safeguard abatement investments.

5.2 Taxation, Taxation Subsidies and Carbon Tax

Economists often view environmental taxes as the most probable instrument for environmental policy, and they thus tend to use them as a point of reference for other instruments. A pure environmental tax is referred as a Pigovian tax if it is set equal to the marginal social damage of activity, e.g. emissions[40] (Sterner 2003).

Greenhouse gas emissions can be taxed, and their taxation can be levied as input or output taxation (Sterner 2003). Under a carbon tax, policymakers would thus levy a fee for each ton of CO2 emitted or for each ton of carbon contained in fossil fuels. The tax would motivate agents to cut back on their emissions if the cost of doing so was less than the cost of paying the tax. As a result, the tax would place an upper limit on the cost of reducing emissions, but the total amount of CO2 that would be emitted in any given year would be uncertain (Congressional Budget Office 2008).

As a substitute for the international emission trade’s binding international or national emissions limits, harmonized carbon taxes could be implemented. Under this approach, countries would agree to penalize carbon emissions at an internationally harmonized carbon price or carbon tax. The carbon price might be determined by estimates of the price necessary to limit GHG concentrations or temperature changes below some level thought to be dangerous interference, or it might be the price that would induce the efficient level of control (Nordhaus 2008).

There is no international experience of this approach in the environmental arena. Nevertheless, there is extensive international experience of the use of harmonized price-type measures in fiscal and trade policies, such as the harmonization of taxes in the European Union (EU) and harmonized tariffs in international trade (Nordhaus 2008). Furthermore, it should be remembered that European Union seriously considered a carbon tax prior starting the Emission Trading Scheme.

[40] See Chapter 3.8, Figure 9

Renewable energy generation can be supported directly or indirectly via the tax system. Forms of direct taxation include tax exemptions or refunds of energy taxes, tax deductions for renewable energy power buyers, renewable energy generation, or tax exemptions for investments in small-scale renewable energy generation. SO2, CO2 and NOX taxes, on the other hand, favour indirectly the development of renewable energy generation (Paun 2004, Enzensberger, Wietschel et al. 2002).

One example of a highly effective, tax-based instrument for renewable energy generation is the United States' production tax credit (PTC). The PTC reduces the price of wind-generated electricity by roughly 2 cents/kWh[41] on a 20-year level basis (Wiser, Bolinger et al. 2007). Connected to other subsidies, such as renewable portfolio standard (RPS) "the United States green certificate", it has been quite generous and has thus made wind power investments attractive to electric utilities and other investors. Created through the Energy Policy Act of 1992, after 1999 it was always reinstated for short time periods only. This led to boom-bust cycles in the industry (Lauber 2004). PTC's effect is well presented by Figure 14, which shows the remarkable changes in the new annual capacity.

[41] EUR/USD = 1.3617 → USD 0.02 = EUR 0.0147 (8.1.2009) (Bank of Finland 2009)

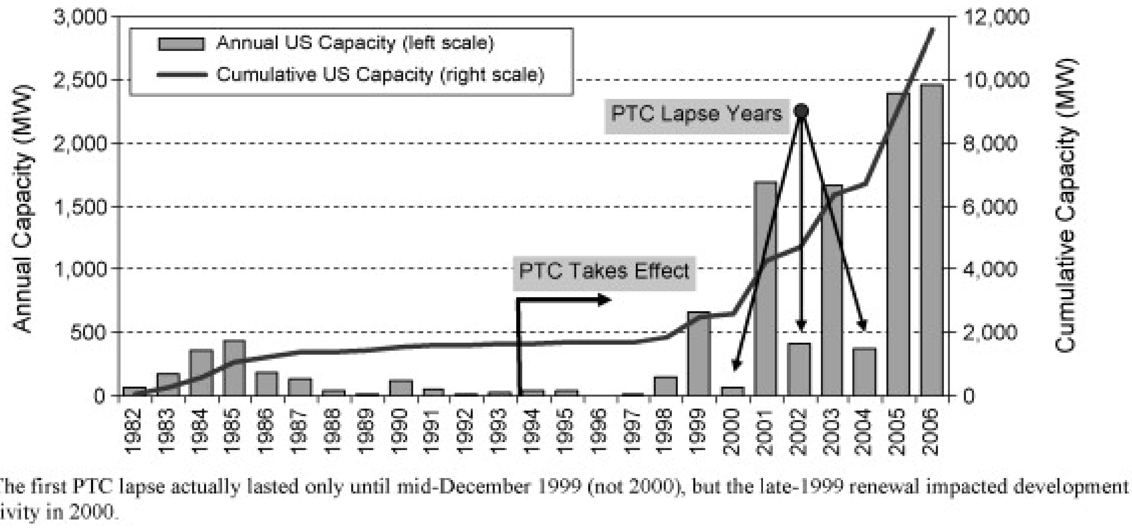

Figure 14: United States Annual and Cumulative Wind Capacity (Wiser, Bolinger et al. 2007)

Even though PTC was seen as being effective when active, Wiser, Bolinger et al. (2007) points out that it did not create a very healthy market base for the long-term renewable energy generation investment development. There are quite a few possible negative impacts of the PTC expirations and short-term extensions that generated boom-bust cycles. Uncertainty in the near-term future availability of the PTC may have undermined rational industry planning, project development, and manufacturing investment. In addition, it might have eroded the long-term research and development spending and made rational transmission expansion planning very difficult, as well as causing peak construction prices during the boom period, thereby leading to higher supply costs and lower levels of new wind project capacity additions (Wiser, Bolinger et al. 2007).

5.3 Green Certificates

The green certificate (GC) is a market-based quota mechanism that is established in Belgium, Italy, Poland, Romania, Sweden, and the United Kingdom in Europe (Fouquet, Johansson 2008) (see Figures *2* and *3*). It is also used in the United States where it is called the renewable portfolio standard (RPS). In these systems a defined member of the electricity supply chain, be it consumer, retailer, distributor, or producer, has to present a fixed minimum quantity of certificates each year, as set by a public authority (Morthorst 2003a). The certificates originate per MWh of renewable energy electricity generated. An obligated party thus may generate himself or purchase certificates on a certificate market. The obligated party may pass on the cost of certificates to the consumer (Fouquet, Johansson 2008).

The idea behind this mechanism is that a renewable electricity producer may receive financial benefit in two ways: by selling the electricity on the network at market price and by selling certificates on the green certificate market (Menanteau, Finon et al. 2003). This means that the target of renewable energy under the green certificate system is set by the government and the certificate price is determined by the market as presented in Figure 15 (Fouquet, Johansson 2008).

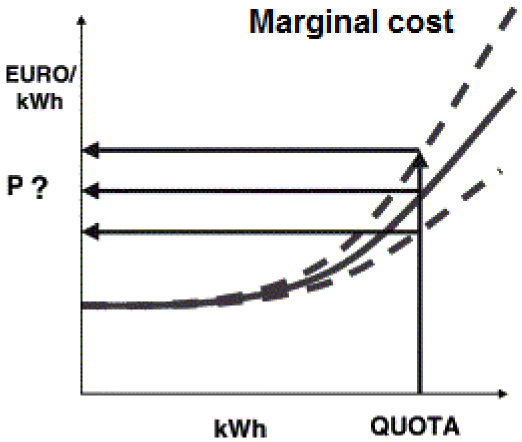

Figure 15: How Green Certificate Works (Haas, Eichhammer et al. 2004).

With more renewable electricity generated than required by the target, the price will fall close to zero, and the investments in renewable energy will have to rely on the revenue collected from electricity sales only. Conversely, if the amount of renewable electricity is not reached, the price might climb very high (Fouquet, Johansson 2008). In the same manner as the emission trade with green certificates, similar flex mechanisms can be used to secure a certain price ceiling or floor price. Furthermore, banking of certificates can be used to cut the volatility of the certificate market price (Amundsen, E. S. 2006).

5.4 Feed-in Tariff

The United States was the first country to introduce a national feed-in law, the Public Utility Regulatory Policies Act (PURPA), in 1978. Feed-in policies were next mobilised in Denmark, Germany, Greece, India, Italy, Spain, and Switzerland in the early 1990s. By 2007, at the very least 37 countries had adopted such policies (REN21 2007).

A feed-in tariff is a “pricing law”, under which producers of renewable energy are paid a set rate for their electricity. Normally this rate is differentiated according to the technology used and the size of the installation. The suitable rate is defined as well as possible, in order to ensure profitable operation and to avoid an unreasonable burden for consumers (Mendonça 2007).

The quantity of renewable energy produced is decided by the markets as Figure 16 describes (Haas, Eichhammer et al. 2004). The payments are guaranteed for long periods that normally cover the significant proportion of the working life of the installation. Grid operators are often obliged to provide priority access to the grid for renewable energy installations (Mendonça 2007). Therefore if the price is set too high the quantity might expand a great deal and cause high total cost of the instrument. Contrarily, if the price is set too low, the targeted quantity might not be reached or even approached (Green Stream Network 2007).

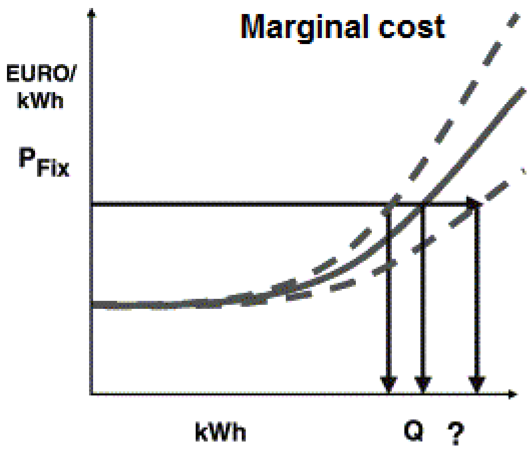

Figure 16: How a Feed-in Tariff Works (Haas, Eichhammer et al. 2004).

The additional costs of the schemes are paid by suppliers in proportion to their sales volume and are passed through to the consumers by way of the premium on the kilowatt hour (kWh) end-users’ price (Mendonça 2007). A modification of the feed-in tariff scheme is the fixed premium mechanism currently used for example in Spain as an optional mechanism (del Río 2008b). The premium mechanism guarantees producers of renewable energy a fixed-rate premium above electricity market prices (del Río, Gual 2007).

5.5 Other Economical Incentives

The main focus of this thesis is with the above-introduced policy instruments. Especially in the case of renewable energy policy instruments, the academic debate has centred around different modifications of feed-in tariffs and green certificates and their relative superiority. In the case of climate politics, the academic debate is still highly concentrated around emissions trade. A few studies are arguing on behalf of carbon tax. As noted above, these instruments are not functioning in a vacuum, and thus other policy instruments might play a highly significant role on their side or as a primary instrument. They also offer a good comparison template and their good qualities might be integrated into the above-mentioned instruments.

5.5.1 Investment Grants

Governments can grant companies, corporations and municipalities assistance for investment projects and surveys that mitigate greenhouse gas emissions, promote renewable energy generation, or help to secure and diversify the energy supply. For example in the Finnish case, where this instrument is actively used, the investment assistance can be between 25% and 40%, depending on the nature of the undertaking (Hiltunen 2004).

5.5.2 Bidding Process

Competitive bidding systems have been used in the United Kingdom under the Non-Fossil Fuel Obligation (NFFO) set up in 1991. This was concerned with different renewable energy technologies. Similar schemes existed in France with the Eole 2005 programme that was set up in 1996 to promote wind energy (Menanteau, Finon et al. 2003).

In the case of competitive bidding processes, the regulator defines a reserved market for a given amount of renewable energy generation and organises a tender between renewable producers to allocate this amount. After the tender, electric utilities are obliged to purchase the electricity from the power producers. The tender focuses on the price per kWh proposed during the bidding process. Proposals are classified in increasing order of cost until the amount to be contracted is reached. Each of the renewable energy generators selected is awarded a long-term contract to supply electricity at the pay-as-bid price. The implicit subsidies attributed to each generator correspond to the difference between the bid price and the market price (Menanteau, Finon et al. 2003). The difference compared to a feed-in tariff is that the price is not set upfront, but through tender. The additional costs are ultimately borne by electricity customers or taxpayers (Winkler 2005).

5.5.3 Niche Market Creation

Niche market creation is used for creating markets for currently expensive emission mitigation technologies or renewable energy technologies that may have future potential but which cannot compete yet in the market place (del Río 2008a, Barreto, Kemp 2008). The niche market principle is to allow technology to benefit from learning effects so that costs reduce and the technology's performance can improve. In time the new technology may then become competitive with the existing technology in the wider market. In other words, the niche market offers a safe growth base for technologies to develop and become competitive in order to be able to compensate incumbent technologies in future (Kemp, Schot et al. 1998) (Foxon, Pearson 2008). For example, a niche market can be developed by setting government technology procurement programmes, such as the heat pump programme in Sweden (1995-1996) or compact fluorescent lightning programme in the United States in 1998 (Lund 2007).

Niche market creation is not a precise instrument, and hence it could be upgraded to be one of the sub-categories. Green certificates, for example, are one way to create niche markets (Midttun, Gautesen 2007). In this thesis I have down-graded it inside other economic incentives. However, it could be put under the regulations and standards category as well. The best categorisation for niche market creation would be creating markets.

5.6 Regulations and Standards

Regulation and standard policy instruments are based on demand and control, and nicknamed "sticks". This refers to forcing the relevant actors to behave in the desired manner. The market players are forced by law to reduce their business options to a set of behaviours defined to be acceptable for the authority concerned (Enzensberger, Wietschel et al. 2002). Regulations might make producers responsible for their waste production, prohibit the use of certain harmful substances, set limits on emissions, enforce certain technical standards, restrict certain activities in special areas such as nature reserves or designate car-free areas in cities, and control land use planning (Ministry of the Environment 2009).

Regulatory standards are the most common form of environmental regulation. Two broad classes of regulatory standards are technology and performance standards. Technology standards for example may mandate specific emission abatement technologies or production methods. For example, environmental permit permission may be based on Best Available Techniques Not Entailing Excessive Costs (BATNEEC). Performance standards demand specific outcomes per unit of product. In this context, where a technology standard might demand specific CO_2 capture and storage methods from a power plant, a performance standard would limit emissions to a certain number of grams of CO_2 per kilowatt-hour of electricity generated (IPCC 2007a).

Most often, economic policy instruments are based on regulative policy. The EU's emission trading scheme is based on the Kyoto Protocol, and European member-states' national renewable energy policy schemes are guided strongly by EU directives[42].

5.7 Information Instruments

"Sermons", such as public disclosure, labelling programmes, or awareness and education campaigns are implemented to guide consumers as well as companies to make better-informed choices. Information instruments can be used on their own or to improve the effectiveness of other instruments (IPCC 2007a).

[42] See Chapter 2.2.2

5.8 Research and Development

Versatile research and development (R&D) can enable the emergence of new innovations and the advancement of existing technologies. The key principle of most policy instruments for climate policy and renewable energy generation is to boost R&D indirectly (IPCC 2007a). Hence R&D can be seen as a by-product of almost all the above-mentioned policy instruments. However, R&D can and should also be subsidised directly. Direct R&D policies, for example R&D grants, should be implemented especially in the cases of new potential technologies that are in the early innovative phase of the product cycle (Midttun, Gautesen 2007). Other direct R&D policies include for instance the enhancement of international co-operation and knowledge sharing.

5.9 Voluntary Instruments

Companies and other organisations may want voluntarily to adopt a variety of market-based measures to highlight their own contributions towards improving the environment (Ministry of the Environment 2009). This is done for public relations, insurance rebate, and especially for image reasons (Sterner 2003, IPCC 2007a, Ministry of the Environment 2009). Voluntary instruments can appear highly attractive, especially in the cases when there is for instance a lack of resources to control and monitor polluting behaviour. Furthermore, they can be implemented by authorities to show the future way and give a hint that “Sticks” may be used in the future if voluntary instruments do not have the desired effect (Sterner 2003). Voluntary instruments include energy-saving agreements as well as commitments to continuous environmental improvements through EMAS or ISO 14001 environmental management systems (Ministry of the Environment 2009).

5.10 Other Policies

It is often noticed that other policies may play a key role in how well policy instruments for climate policy and renewable energy generation work. As mentioned in earlier chapters, the impact of climate policy can be adversely affected by non-compliance by major emission countries, but as well as by policy failures with other policies like fossil fuel subsidies. In addition, policies for land use, structural reforms, population, and international trade among many others play a crucial role in how well climate policy can work (IPCC 2007a).

Planning permission procedures, land rent, or loan granting and grid connection polices can play a extremely important role for the success of renewable energy generation policy instruments (Butler, Neuhoff 2008). Stumbles with these might cancel out the success of an otherwise well-planned policy.

Policies such as those affecting trade, consumption, and social development goals have a strong impact as well. For example, the most cost-efficient equipment might be hard to acquire, or the best service impossible to import if high trade barriers exist. Thus it is crucial to an understanding of the big picture to try to resolve in the best way possible the direct and indirect causes and effects that other polices have on policy instruments and vice versa.

5.11 Main Issues Affecting Policy Decision

When policies are implemented, stakeholders are primarily interested in two things: how it will affect us, and how it will affect our "competitors" (Sterner 2003). Different stakeholders have different interests when policies are implemented. Figure 17 below showcases some of the different interests renewable energy generation policy creates.

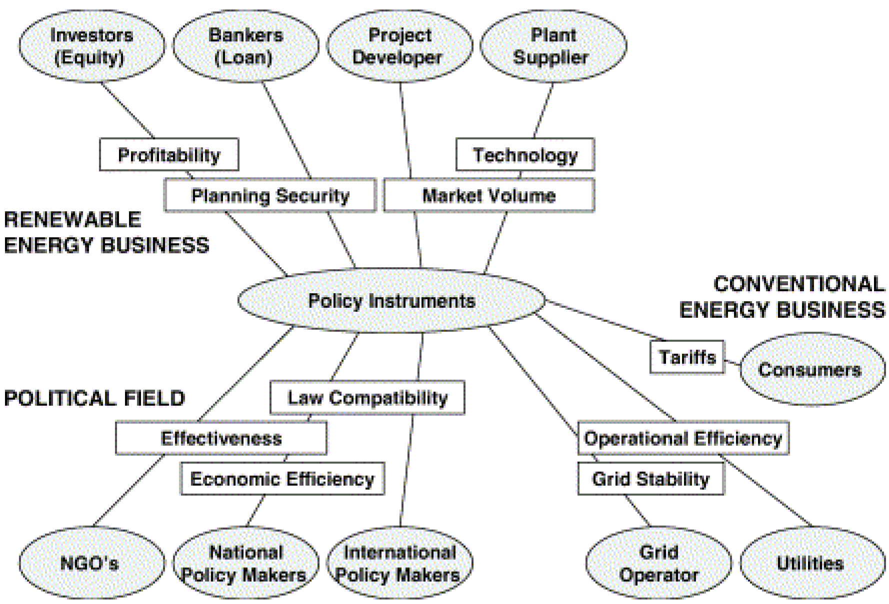

Figure 17: Stakeholder Interests in Renewable Energy Policy Instruments (Enzensberger, Wietschel et al. 2002).

Different stakeholders stress very different issues. For example, investors and bankers, who can provide equity and loans for new renewable energy projects will require interest and a risk-adequate profit for their investment. Project developers and plant suppliers are interested in the future market volume. The conventional energy businesses are interested in what will happen to their present situation. Consumers are interested in low or lower costs. System operators have to ensure a reliable and technically efficient electricity supply within a market. In this respect, system operators will be especially interested in the high technical efficiency of a policy instrument (Enzensberger, Wietschel et al. 2002).

The settlement of the necessary administrative tasks related to policy instruments can result in significant transaction costs. Agents may thus request financial compensation, a high administrative efficiency of a policy instrument, and/or a possibility to pass these costs on to their end-customers. Non-governmental organisations (NGOs) and politically active ecologists may on the other hand demand a high effectiveness from a new environmental policy instrument without considering in detail what costs a specific measure might cause for certain market players. Finally, national as well as international policy-makers have to try to find a compromise that is possible to implement (Enzensberger, Wietschel et al. 2002).

For this reason, the viewpoint from which we scrutinise the situation depends in great measure on what policy instrument is preferred. The next chapter will examine further what are the suitable criteria that might be used for wider evaluation of policy instruments. Depending on the predominant market circumstances, there are some rules of thumb that are enjoy a high degree of consensus from the viewpoint of total wellbeing, and which can be used when selecting policy instruments.

Firstly, with heterogeneity in abatement costs and everything else remaining the same, economic instruments are preferred over regulations and standards (Sterner 2003, Nykänen 2006, Romstad 2000). On the other hand, if abatement costs are highly homogeneous, possible cheaper administrative costs might make regulation and standards a better solution compared with economic instruments (Romstad 2000). In the case of greenhouse gas emissions, the abatement costs are seen to be highly heterogeneous, and as such economic instruments may be preferred.

Secondly, turning to the uncertainty about marginal costs and/or benefits, when marginal costs are steeper than the marginal benefits, price-type policies should be preferred. On the other hand, if marginal costs are flatter than the benefits curves, quantity-based policy instruments should be preferred to meet the targets most efficiently (Weitzman 1974) (Sterner 2003, Söderholm 2008a). Figure 18 below illustrates a framework for analysing the economic efficiency of the two climate policy support mechanisms: price- and quota-based, with uncertainty on abatement costs and/or benefits prevailing.[43]

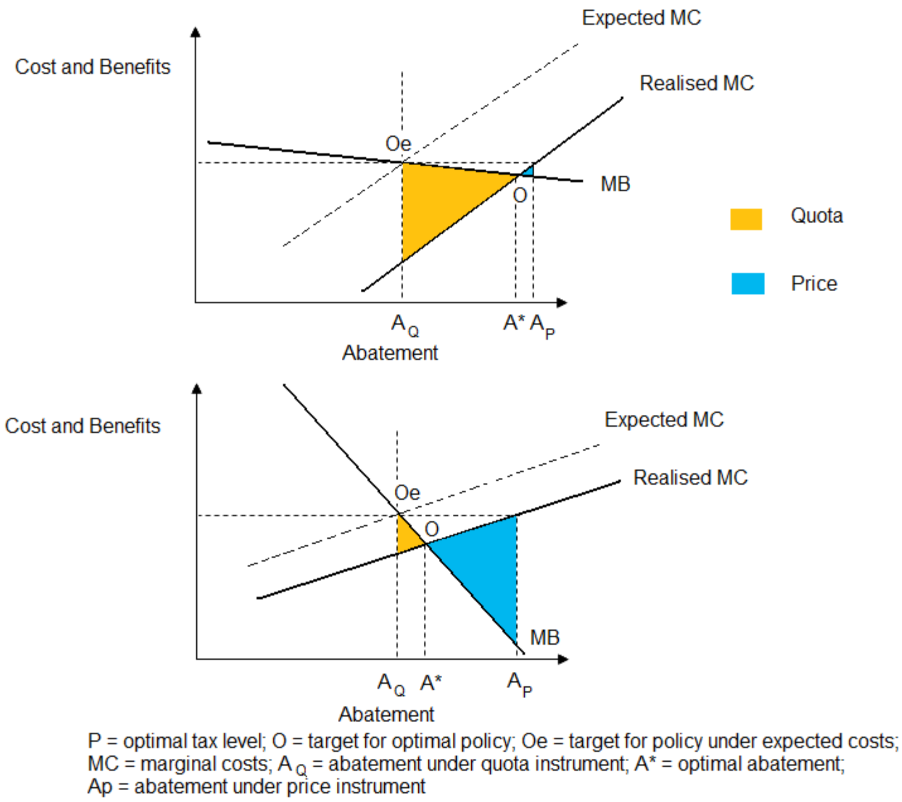

Figure 18: Deadweight Loss of Price versus Quantities[44]

An economically efficient abatement requires that the price or quota be at the level where the marginal benefits (MB) equal marginal costs (MC)[45]. As shown in Figure 18,

[43] For the same proof from the renewable energy generation policy instruments' point of view, see (Söderholm 2008a).

[44] Imitates figures presented in (Weitzman 1974) and (Sterner 2003).

the price and quota instruments do not lead to symmetric under- and over-regulation, but to radically different end results. With overestimated marginal cost (dashed lines), the regulator will aim for Oe instead of O, and the price level (P) will be too high, leading to over-abatement (Ap). On the other hand, regulation will be too light (at AQ), but the size of the economic welfare cost caused, as measured by deadweight[46] losses, depends on the relative slope in the marginal abatement and cost curves. "*If errors in judgement are assumed and the sum of expected consumer and producer losses minimised, then the expected losses turn out to be different with price- and quota-based instruments, as shown by the relative size of the deadweight triangles*" (Sterner 2003, Söderholm 2008a).

Thus, if the marginal benefits of abatement are flat and the marginal abatement cost steep, then one can predict with quite good accuracy that the "price" for emission and the loss due to the price-based instrument will be small. The exact quota level is difficult to predict precisely, and the risk of large cost is considerable with the quota-based instrument. The opposite applies when the marginal cost of abatement is flat and the benefit of abatement (or pollution damage) is steep. The deadweight loss is large, owing to the excessively high level of the price-based instrument, whereas the error level caused by a quota-based instrument is small (Sterner 2003).

Thirdly, in the case of fast technological progress, a quota-based instrument, e.g. emission trade, may result in less abatement than a price-based instrument, e.g. tax, because progress makes allowances cheaper, and lowers the incentives more than a tax would. For similar reasons, emission trade might lead to stronger price-based incentives in the presence of economic growth or inflation, as these factors raise the allowance price above that of a fixed tax.

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[45] See Chapter 3.8, Figure 9.

[46] Deadweight losses: "Can be applied to any deficiency due to an inefficient allocation of resources. Lost production due to inaccurate forecasting for labour is an example of a deadweight loss" (Investopedia 2009).

Last but not least, the long-term and short-term goals should be examined from various perspectives. For example, in the short-term the renewable energy generation instrument should be designed to encourage penetration of currently available renewable energy technologies. Furthermore, this should drive the long-term technological improvement of the renewable energy technologies in order that these can compete directly without usage of price or quota instruments. "*The difficulty confronting policymakers is that these short-term and long-term goals are unlikely to be perfectly aligned, since technological progress is endogenous. In other words, policies enacted today affect current and future R&D behaviour, which in turn affects innovation rates and technological progress*" (Lesser, Su 2008). Most importantly, these effects might be counterintuitive: increasing subsidies may, in fact, adversely affect the rate of technological progress. This is because the relative expected returns to renewable energy technology investments favour technologies that are more promising in the long term rather than in the short term; too great a subsidy may encourage more rapid growth of near-term renewable energy technologies, thus diverting investment resources away from medium-term renewable energy technologies. Too great a subsidy may also encourage investment in renewable technologies that are highly speculative and far removed from practical application. "*If so, the probability of technological setbacks will increase, leading to increased perceived financial risk of investment in such technologies and reducing incentives for further investment"* (Lesser, Su 2008). Therefore policymakers must determine what will maximize the rate of technological improvement for each technology encompassed (Lesser, Su 2008).

6 Criteria for Judging Policy Instruments

This chapter first explores the requirements for judging the criteria for selecting policy instruments, and introduces the criteria that were chosen for this survey. In this thesis, seventeen different criteria have been selected, from effectiveness to technology maturity neutrality. These criteria are then used in the next chapter to highlight what criteria were used in selected research papers, what criteria have been omitted, and what might have been good to include.

In the decision-making context, criterion is defined as some sort of standard by which one particular choice or course of action would be judged to be more pleasing than another (Belton, Stewart 2002). Sterner (Sterner 2003) emphasises that economists generally presume that the most important criterion for society is welfare maximisation, and that this welfare can be measured as a function of individual utilities. Because the utility and welfare functions might be too complicated to be operational, it is common to have several unrelated sub-criteria (Sterner 2003).

Another way to express and see welfare maximisation is cost-benefit logic. It summarises neatly the general principle in selecting policies that cost money one way or another. Policy benefits should be higher than the policy costs (Pearce 2002). Here a cost can be seen as any lost of wellbeing and a benefit is any gain in wellbeing. Hence it could be the ultimate criterion to judge an instrument. Just select the one policy or the policy portfolio that gives the highest benefit/cost ratio. It is very difficult to calculate all the benefits or costs in monetary terms and thus it is common to set the targets and choose the policy instrument based on some subjectively relevant principle(s), in other words sub-criteria (Pearce 2002).

This thesis presents a selection of seventeen sub-criteria that can be seen in Table 7. These criteria are neither perfectly clear nor completely separable. Nevertheless, they should give at least a wide theoretical test and estimation of the basis for different policy instruments, and in this way help to spot the right policy for certain goals and situations.

Table 7: List of Criteria for Judging Policy Instruments (Continues two next pages)

1)Effectiveness	How well goals that support initial vision, mission, and strategy are achieved. In other words, the instruments that achieve desired goals better and produce more powerful effects than alternative instruments can be said to have a higher degree of effectiveness (Sterner 2003, Aldy, Barrett et al. 2003, IPCC 2007a, Menanteau, Finon et al. 2003).
2)Cost-Efficiency	The instrument that achieves goals at the least cost has the best cost-efficiency. Indeed, being cost-efficient means producing results with as little wasted effort as possible. Specifically it is the ability to carry out actions with least marginal cost. From a time perspective it can be divided into two sub-units, statistic cost-efficiency and dynamic cost-efficiency. **A) Statistic cost-efficiency** Today, a single time period's costs are minimised. It is described well by the equi-marginal principle, which expresses that a necessary condition for the least-cost provision of a particular quantity is that the marginal costs of the multiple sources of supply equate (Kildegaard 2008). **B) Dynamic cost-efficiency** It requires that the present value of the costs of the delivery of the flow of practices be minimised. In other words, dynamic cost-efficiency takes into consideration impacts and outcomes of today's decisions for the future. It weighs up cost-efficiency from the point of view of what will be the path or strategy that gives the lowest cost in the long run (del Río 2008a).
3)Lack of Bias	Are the desired changes similar to the goals? Are there many side-effects that were not predicted beforehand? This criterion evaluates more the instruments' implementation than the instruments themselves. With the help of empirical studies it might be possible to determine which instruments have had more tendencies to have biases between desired and achieved goals.
4)Equity and Fairness	Estimates how fairly costs and benefits are directed to the right agents, if these can be specified. In the case of equity and fairness it may be hard to be objective, because they are seen differently by different people, for example subject to the cultural background of the observer (Sterner 2003, IPCC 2007a, Nordhaus 2008).
5)Effects on Economy	Estimates how strongly the instrument changes the economic balance between initial consumer, investor, and government in the short as well as in the long run, i.e. intertemporally. Economists typically point out that there is no such thing as a free lunch. In one way or another things that seem to be free or even wealth-enhancing are always paid for in some way. Finding an all-positive solution inside of economies is often impossible. Criterion functions as a referee of where the money is taken from and where it is distributed. Therefore, it should be strongly in conjunction with consumers', investors', and government's instrument approval prospects at the same time as it overlaps strongly with the fairness and equity criterion.

6)Flexibility	Judges how easily the instrument is adjusted in the presence of new information. Is there is a possibility to adapt and correct an instrument afterwards in a situation where some new item of information proves that the instrument is not functional, and is the instrument rigid and hard to adjust to a changed environment. This criterion is partly an antonym for investor's predictability.
7)Rent-Seeking	The criterion judges how much the instrument may cause manipulation attempts among promoted stakeholders. Are subsidy levels strictly specified by this instrument, or are there possible ways to affect individual subsidy amounts, for example by lobbying? (Sterner 2003).
8)Investor's Predictability	Judges how foreseeable the instrument's effects are. How well can investors take into account beforehand the instrument's impacts for the investments and how possible are the changes during the investment life-cycle (Arasto 2006).
9)Author's Predictability	The criterion judges how foreseeable the instrument's effects are from the authority's point of view. How well instrument's future cost effects can be predicted to avoid an unexpectedly severe burden. Author's and investor's predictability will collide in most of the cases.
10)Decision-Making Feedback	Estimates how well and how easily authority can get ex post feedback of the instrument, and how simple is the ex post feedback to understand. For example, can cost be calculated rapidly from a budget or does the total cost hide behind multiple factors?
11)The Complexity of Decision	Does the authority or international organisation have to make decisions without well-documented and unambiguous background data? Is it easy for the authority to make wise decisions that relate to the instrument or does the authority have to resort to guesswork? How hidden is the future prediction and is it possible to make major mistakes that might have radical effects in the future?
12)Ease of Control	Judges how simple policy implementation, monitoring, and surveillance are. For example, does the author need a light or heavy administrative structure around the instrument and how much of new resources have to be added? Is it expensive and does it need administration during the whole life cycle? Are there lots of decisions to be made, for example small projects, or is it well harmonised from that point of view?
13)Functionality in Market Environment	Judges how well the instrument works in a market environment. Neither free market competition hinders the instrument's effectiveness nor does the instrument hinder market functioning. This overlaps partly with the connectability criterion.
14)Connectability	How easily the instrument can be integrated, used, and implemented with other instruments and policies. Features of good connectability are that the instrument does not overlap or generate confusion between other instruments or policies and it functions well in an open market environment (Arasto 2006).
15)Harmonisation Qualities	Measures international connectability. How easily is the instrument made consistent internationally? For example, features of good harmonisation ability are that it is possible easily, speedily, and fairly possible to apply the instrument internationally, even when different legislation-, culture-, political-, historical-, or infrastructure environments have been taken into consideration. How well does the instrument work in an open market environment? Hindering the effect of other instruments or transgressing international or national legislation are also important viewpoints when estimating an instrument's harmonisation ability.
16)Production Neutrality	Estimates whether all technologies get the same equitable support, or are some technologies preferred over others? (Arasto 2006)
17)Technology Maturity Neutrality	The criterion evaluates how well the instrument takes the technology life-cycle and maturity stage into consideration. Do different technologies, regardless of the maturity stage, have similar possibilities to penetrate into the market and in particular does the instrument diminish the cost gap between different stages of technologies? This criterion can partly be seen as antonym for production neutrality.(Arasto 2006)

These sub-criteria can help us to judge more profoundly how well different policy instruments ex ante would and ex post have reached their goal. As the report of Working Group III (IPCC 2007a) points out, criteria may be applied for example in making ex ante choices among policy instruments as well as in ex post evaluation of the performance of policy instruments.

However, in this thesis the following criteria have been used for the sake of comparing different research. The basic idea is that the occurrence of the criteria helps in defining outcomes. If a certain criterion is not included in the analysis of the research, its non-presence may, at least in part, explain the conclusion. If important criteria for analysis have been left unnoticed, this might change the final result drastically. This might also help to understand the possible differences between the research results if it occurs.

Indeed, criteria selection can play a crucial role in both research and decision-making, and should be done objectively. However, when choosing policy instruments, the estimation of different criteria weightings in a multi-criteria situation is complicated, and frankly it is impossible to be objective. Criteria weights are considered through different parties' dissimilar interests, favoured choices, and the importance they attach to different things. For example, culture, history, other policies, psychology, and expectations all add their own spice to the decision-making and might make different criteria weightings more favourable depending on these factors (Sterner 2003). Hence even though a certain criterion is taken into consideration, how much it is stressed may influence considerably the conclusion of the research. In this respect remembering the big picture plays a crucial role. In the case of a policy instrument performing well with a sizeable share of different criteria and achieving seemingly important goals, this might still be worthless if at the same time "total" welfare is eroded greatly.

Another caution that has to be highlighted is that when analysing policy instruments, most policy instruments do not have identical benefit streams. In this case, we have to be careful when using and especially stressing certain criteria to compare different policy instruments. For example, in the case of relying on the cost-efficiency as a key criterion between two policies, we might end up selecting a low-cost policy instrument that is not fundamentally economically smart. That is to say, it can advise us to take "*a fast train to the wrong station*" (Aldy, Barrett et al. 2003). Owing to matters like this, once again, mapping the big picture is important.

7 Comparison of Applied Approaches in Policy Instrument Research

This chapter introduces the debates, important questions, and phenomena that arise from the academic research inside the scope of this thesis. How these questions, debates and phenomena were selected is explained in the research methodology in Chapter 1.5. Each sub-chapter introduces one interesting academic debate or phenomenon that I have seen important to highlight, also introducing new research. Depending on the subject, the analysis criteria are either included or left out. In each chapter, each piece of research is examined and introduced one by one and the main focus and results for each of them concerning the chapter's topic are highlighted. In some sub-chapters the empirical data used in the researches is highlighted. Because of the extensiveness of some of the questions, debates, or phenomena, all relevant new pieces of research have not been included. Some of the most relevant research that was found, but not included because of limited resources, is added at the end of the introduction tables.

The selection process for the significant questions, debates, and phenomena has included partly subjective processing. Thus it is only natural that there might be some important issues within the scope of the thesis that are not included in this chapter. It is possible that another researcher might have ended up with a different focus altogether. Nevertheless, it can be argued that the issues introduced below are of great importance and should be given further evaluation in the future research.

7.1 Taxation versus Emission Trade versus Hybrid

After emission trading was locked as a main policy instrument for the Kyoto Protocol and implemented in the European Union (EU), there has not been too much public debate about a possible turnaround with the main international climate policy instrument. Hence it is obvious and understandable that a major share of the current academic debate is concerned with criticising, repairing, or applauding emission trade. However, research exists concerning whether harmonised carbon tax or hybrid mechanisms[47] would in fact function as better policy instruments for climate policy than emission trade. Some researchers have challenged the emission trade path and argued that there are better ways to fight climate change and implement a price on greenhouse gas (GHG) emissions than the present Kyoto Protocol mechanisms. In addition it is interesting point that before Emission Trade Scheme was implemented, Europe was quite enthusiastically driving a tax based instrument as an alternative for emission trade. However, this thesis emphasises only the current debate. Table 8 presents the found and selected research concerning the issue.

Table 8: Selected Appraised Authors Their Bias, Main Focus and Results (Continues next page)

Author	**Bias tax / emission trade**	**Main focus**	**Main result for sub-chapter's issue**	**What criteria where included in the analyse**
(Aldy, Barrett et al. 2003)	tax/ hybrid	A critical review of the Kyoto Protocol and 13 alternative policy recommendations	Climate policy implementation should concentrate on a market-based approach. Price-based mechanisms might be more functional (carbon tax or hybrid). Review concludes that new information about climate change should be used to modify Kyoto agreement in the future.	Effectiveness, Cost-Efficiency, Lack of Bias, Equity and Fairness, Effects on Economy, Flexibility, Rent-Seeking
(Congressional Budget Office 2008)	Tax	Evaluation of tax, emission trade, and hybrid mechanism	From efficiency, ease of implementation, and international consistency criteria perspectives, a carbon tax seems to be the most feasible alternative.	Effectiveness, Cost-Efficiency, Equity and Fairness, Effects on Economy, Flexibility, Rent-Seeking, Decision-Making Feedback, The Complexity of Decision, Ease of Control, Connectability, Harmonisation Qualities

[47] A hybrid instrument is an instrument where an initial quantity target is coupled with a price ceiling, safety valve, or trigger price introduced in emission trade sub-chapter. A hybrid instrument: "will perform at least as well as either a pure tax or permit scheme" (Pizer 2002).

(Ellerman, Joskow 2008)	Emission trade	Evaluation of the European Union Emission Trading Scheme's trial 2005 to 2007 period	With the help of the European Union Emission Trading Scheme's (EU ETS) trial period experiences, cap and trade-based emission trade can be repaired to function well. Although having plenty of rough edges, it was still able to put a transparent price on carbon dioxide. With the help of different allocation (more auctioning) and banking methods, it can be adjusted to meet the windfall profit and the price volatility problems. This concrete experiment from EU-ETS might foster cap and trade forward in the international selection process.	All except Production Neutrality and Technology Maturity Neutrality
(Nordhaus 2007b)	tax/ hybrid	Prices versus quantities in economies of climate change	Article suggests that a price-type instrument such as harmonised carbon tax would be more efficient than a quantity-type, such as those found in Kyoto Protocol. Harmonised carbon taxation mechanism should be considered and brought to the table when discussing beyond the Kyoto agreements, because of its advantage in volatility-, efficiency-, implementation- and anti-corruption issues amongst others.	All except Production Neutrality and Technology Maturity Neutrality
(Nordhaus 2008)	Tax	The economics of climate change modelling	International treaty should be made as close as possible to optimal policy, thus avoid locking into poorly designed policy like Kyoto protocol. One possible efficient approach could be internationally harmonised carbon taxes.	All except Lack of Bias, Production Neutrality, and Technology Maturity Neutrality
(Pizer 2002)	tax/ hybrid	Comparison of efficiency of price and quantity climate policy instruments.	Simulations indicate that the expected welfare gain from the optimal price policy is five times higher than the expected gain from the optimal quantity policy. Equally, politically attractive hybrid policies offer great gains compared to quantity policy. Therefore, hybrid policy might be an interesting alternative for either quantity (cap and trade) or a pure price (tax) system.	Effectiveness, Cost-Efficiency, Flexibility, Effects on Economy, Investor's Predictability
(Stern 2007)	Emission trade/ tax	The economics of climate change	The key issue is to implement price for emissions; this can be done either with emission trade or tax.	All criteria included. Nevertheless, some have argued that Stern has been optimistic about the abatement costs while overestimating the adaptation costs.

(Vehmas 2005)*
(Wagner, Wegmayr 2006)*
*Additional relevant material that was found but not included in the analysis

To the question of which instrument - emission trade, carbon tax, or hybrid - would be the best, Weitzman answers the following: "From a strictly theoretical point of view there is really nothing to recommend one mode of control over the other" (Weitzman 1974). Then again, in the real world, the preferred instrument depends on several factors, which are far from being clear-cut. The handiest way to solve which of these instruments is the best would be by calculating the cost and benefit ratio or welfare gains for all of them. This has been done in several studies. For example in the simulations carried out by Pizer (2002), he pointed out that welfare gains from optimal price-type climate policy (carbon tax) would be five times higher than the expected gains from the optimal quantity-type policy (emission trade). Furthermore, a hybrid policy would be an attractive alternative to either a pure price or quantity instrument. Nordhaus (2008, 2007b) ended up with similar results in his simulations.

However, these kinds of simulations are adjusted with initial value guesswork. It also requires that everything is measured in monetary terms, which is extremely complicated and imposes a huge amount of dilemmas that cannot be resolved by unambiguous definitions. Thus to be able to understand the differences between the instruments it is preferred to examine the instruments using different criteria (Pearce 2002).

Emission trade is a highly effective climate policy instrument if there is a strict quota, which will ensure that the target will be met. Carbon tax, on the other hand, might produce a result where the target is not reached if the tax is too low, or then it is overshot if the tax is set too high (Congressional Budget Office 2008). However, "right" quantity limits are hard to predict, particularly because targets must adapt to different levels of economic growth, uncertain technological change, and evolving science. Thus there will be a great challenge in how to take due account of changing conditions while setting the target (Nordhaus 2008).

Emission trade is an efficient and unbiased way to meet the set target. The price of allowance will adjust in accordance with the supply and demand (Ellerman, Joskow 2008). The carbon tax, on the other hand, might cause an oversized burden for emitters if the level is set too high (Congressional Budget Office 2008). However, in the case of high uncertainty of the right target, the cost-efficiency of emission trade is seen to deteriorate.

"The reason is that the benefits of emissions reductions are related to the stock of greenhouse gases, while the costs of emissions reductions are related to the flow of emissions. This implies that the marginal costs of emissions reductions are highly sensitive to the level of reductions, while the marginal benefits of emissions reductions are insensitive to the current level of emissions reductions" (Nordhaus 2008).

In other words, this means that the marginal benefits of emissions are flat and the marginal abatement cost are steep, which indicates that carbon taxes are more efficient than quantitative mechanisms such as emission trade, as was demonstrated earlier in Chapter 5 (Nordhaus 2008). If marginal benefits would be steep compared to marginal abatement costs, quantity instruments would be preferred, which might well be the case after a certain temperature increase has occurred (Stern 2007). However, in that case, i.e. under a strongly kinked benefits curve, the paramount concern would be to make drastic cuts in emissions and the actual choice of policy instrument would be relatively unimportant (Pizer 2002).

To avoid competitive advantages and unfairness between different national industries, similar carbon tax rates or emission trade schemes should be preferred (Aldy, Barrett et al. 2003, Congressional Budget Office 2008). However, Nordhaus implies that *"Strong and internationally harmonized steps to raise the price of carbon, whether by taxes or by quantitative restrictions, will have substantial impacts on the distribution of income. This raises issues of fairness and ability to pay, both among nations and across households within a nation"* (Nordhaus 2008). In addition to this, questions about who is to be responsible for paying and who will get the biggest distribution of benefits from abatement might cause conflict between both nations and households (Aldy, Barrett et al. 2003). Especially developing countries might be reluctant to cooperate at least at the same level as developed countries, for the obvious reason that they have not caused the problem and they have the most to lose (Nordhaus 2008). To some extent, these issues can be handled by favourable allocations of emissions allowances under the emission trade scheme. In the same way, part of the carbon taxation revenues could be used to alleviate the economic hardships of developing countries (Nordhaus 2008). This could be done as well with the emission trading scheme, if an auction mechanism were to be used (Ellerman, Joskow 2008).

As new knowledge comes along, neither fundamental emission trade nor carbon tax proves to be very flexible policy instruments. It often takes time to change tax regulations, and the normal preference is to set emission trade periods for at least a few years (Aldy, Barrett et al. 2003). However, with both cases, adjustment mechanisms could be implemented.

To avoid rent-seeking with the carbon tax, emission trade, or hybrid schemes the participating countries should implement similar systems that would include a similar level of monitoring and enforcement provisions. If this is not the case, rent-seeking would most probably emerge (Congressional Budget Office 2008). Rent-seeking might be especially high with the emission trading scheme, because there is a huge money flow in the allowances, and cheating could be worth billions. Carbon tax might not cause such a high inducement for rent-seeking, because there are no allowances transferred to countries (Nordhaus 2008).

Uncertainties affect prices. Because supply, demand, and regulatory conditions develop unpredictably over time, emission trade schemes are likely to cause volatile trading prices of carbon emissions. *"Price volatility for allowances is likely to be particularly high because of the complete inelasticity of the supply of permits, along with the highly inelastic demand for permits in the short run*"(Nordhaus 2008). This has been the case with the European emission trading scheme as well with the U.S. sulphur dioxide trading scheme. This has therefore hampered predictability for both the investors as well as the author. However, this could be partly avoided with hybrid mechanisms or by implementing banking mechanisms (Ellerman, Joskow 2008).

Both emission trade and carbon tax will cause a vast amount of indirect effects. Hence it is quite hard to get well-aimed decision-making feedback. However, in the case of emission trade the price of carbon - and conversely in the case of carbon tax the amount of emissions - will give very good view of the big picture and inform decision-makers how well the prediction went.

There is high complexity when deciding the optimal price of the carbon tax as well as in determining the cap in emission trade schemes. Depending on how one sees the uncertainty situation mentioned above, the inefficiency risk is higher or lower with carbon tax. Allocations made by grandfathering, relative to auctioning, make the complexity increase in the case of emission trade. Here the hybrid mechanism may help decision-makers avoid serious mistakes that depend on the level of uncertainty (Congressional Budget Office 2008, Nordhaus 2008, Sterner 2003). A hybrid instrument will perform at least as well as either carbon tax or emission trade (Pizer 2002).

The ease of control depends to a large degree on how the instrument is implemented: upstream, downstream, or somewhere in the middle. Upstream, i.e. high level, carbon tax or emission trade would not require monitoring emissions as well as being relatively easy to implement. However, emission trade will need a new administrative infrastructure to check allowance transfers and holdings. On the other hand, carbon tax might be easy to build on the administrative infrastructure for existing taxes (Congressional Budget Office 2008). When we move to downstream, the actors are multiplied considerably. This brings a greater control base. In conclusion, the ease of control is highly dependent how the instrument is implemented.

Emission trade, carbon tax, and hybrid solutions will distort markets by entailing new balance that is supposed to be at least more environmentally friendly. Compared with strict regulation, they are much more market-friendly. However, this of course once again demands that at least all similar global markets are treated fairly, and thus carbon leakage and other negative effects are not encouraged (Aldy, Barrett et al. 2003).

When carbon tax and emission trade are connected with other policies or they are harmonised internationally, they bring different dilemmas into play. For example, in the case of carbon tax, if an international carbon tax is set to 50$/ton of carbon dioxide, it can be easily undermined if a country sets for example a 50$ subsidy on coal. Thus, consistency would require comparable verification and enforcement. In the emission trading case, national subsidies or other policies would not have the same effect and would not therefore cause difficulties. However, as mentioned above, rent-seeking might emerge as a problem, because a few countries could undermine the entire linked trading system by inconsistent monitoring and enforcement (Congressional Budget Office 2008). Hence, once again the hybrid instrument could help to abate the incentives for rent-seeking (Nordhaus 2008).

Emission trade and carbon tax as well as hybrid instruments are all production-neutral from a renewable energy generation point of view. In the case of conventional production, low emission production is of course supported. However, in the case of emission trade, if the allowances are grandfathered, some production mechanism might be preferred over another, depending on how the user allocates the allowances. Furthermore, depending on how the instruments are implemented, inconsistencies in production neutrality can occur.

Neither carbon tax, emission trade, nor the hybrid path will take technology maturity into consideration. Thus, if there is a wish to support immature technologies, there need to be technology-specific instruments. However, high carbon taxes and strict emission trade caps give high incentives for low-emission innovations. Nevertheless, they are seen to promote too much by way of short-run innovations and they do not give enough incentive for long-run technology development and innovation (del Río 2008a).

In well-designed policies, abatement and adaptation costs can be kept reasonable. Badly designed ones, then again, are unlikely to make a difference. They will generate substantial costs and might cool the enthusiasm for the whole adaptation process and thus hurt the future possibility to use more efficient approaches. In addition, it is often seen that overly ambitious projects are likely to be full of loopholes, exemptions, and compromises, and thereby might cause more economic damage than benefit (Nordhaus 2008).

Defining which policy should be selected is definitely no easy task. There is evidence that by learning, adapting new information from former experiences, and by correcting observed errors, emission trade can be made to function nicely as a climate policy (Ellerman, Joskow 2008). However, there are academic arguments that price mechanisms, either carbon tax or hybrid tax-quota, should be preferred over emission trade (Congressional Budget Office 2008, Nordhaus 2007b, Aldy, Barrett et al. 2003, Nordhaus 2008, Pizer 2002). For this reason, before locking in emission trade as a number one choice it might be valuable at least to have serious global discussion about the possible alternatives (Aldy, Barrett et al. 2003).

7.2 Feed-in Tariff versus Green Certificates

In the field of renewable energy generation, two policy instruments and their derivatives are currently at the centre of the academic debate. This debate can be summarised as follows: which instrument should be preferred as a primary renewable energy policy instrument, the feed-in tariff or green certificate? Even though there is a great amount of theory in addition to some empirical results to resolve this question, the final statement is far from unambiguous. Depending on how different criteria are weighted or how the instrument is implemented, one can end up with very different conclusions. In the case of feed-in tariff what will be the output depends totally on what is the selected tariff price level. Same case is with the green certificate's selected quantity. It should be also emphasised that even though the focus is with feed-in tariff and green certificates, other instruments should not be forgotten. They might act as valuable components or even as substitutes. Below a selection of authors and their studies are presented.

Table 9: Selected Appraised Authors: Their Bias, Main Focus & Results and Criteria Included (Continues three next pages)

Author	Bias Green Certificate / Feed-in Tariff	Main focus	Main result for sub-chapter's issue	What criteria were included in the analysis
(Arasto 2006)	Neutral	Policy instruments for renewable energy generation – investor's viewpoint	Feed-in tariff is demonstrated to be functional and effective. Nevertheless, it is normally connected with relatively high subsidy level and it does not function well in open electricity markets or with other promotion policy instruments. Green certificates, on the other hand, function well in open electricity markets and in theory it is cost-effective, though other results are also gained.	All except Rent-seeking & Author's Predictability
(Butler, Neuhoff 2008)	Feed-in tariff	Comparison of feed-in tariff, green certificate, and bidding mechanism to support wind power	Empirical study shows that the German feed-in tariff to date managed cheaper price/wind MWh, greater competition, as well as deployment compared with bidding process and green certificate system.	Effectiveness, Cost-Efficiency, Lack of Bias, Equity and Fairness, Effects on Economy, & Predictability
(Carlén 2006)	neutral	Comparison of different feed-in tariff and green certificate models under uncertainty	If future electricity price is highly uncertain, feed-in tariff based on premium is likely to be inferior instrument. On the other hand if future electricity consumption is highly uncertain, green certificate bound to electricity consumption is likely to be inferior instrument. Based on actual market functioning, the green certificate instrument based on fixed quota obligation connected with banking and safety valve mechanism seems to be the most efficient policy instrument to promote renewable energy generation.	Effectiveness, Cost-efficiency (especially dynamic), Effects on economy, Flexibility & Harmonisation Qualities

(Finon, Perez 2007)	Neutral	Feed-in tariff, bidding, and green certificate instruments: comparison from public economic and transaction cost perspectives	Neither green certificate nor feed-in tariff offers an optimal solution in public economic perspective, nor in transaction cost perspective. Hence government should select an instrument in accordance with the relative importance of its objectives.	All except Rent-seeking
(Green Stream Network 2007)	Neutral	Review of costs and advantages of different policy instruments for renewable energy generation	Policy instrument's individual implementation is as important as the selection of which instrument to use. By adjusting the instrument's characteristics, either feed-in tariff can be made to look like green certificate or vice versa.	All except Rent-seeking
(Haas, Eichhammer et al. 2004)	Feed-in tariff	Renewable energy technology's successful and effective promotion	Empirical evidence has shown that in the real world, carefully designed gradual feed-in tariffs are the preferable instrument for a mature technology. However, more important than the choice of the system is the proper design and monitoring of the support system adopted; in this respect the functionality, stability and continuity of a policy-support system are crucial features.	All except Rent-seeking
(Kildegaard 2008)	Neutral	Green certificate effect of over investment risk and long-term contracts	To cut the investor's risk, when green certificate (GC) markets are composed of mostly high-fixed cost technologies, long-term contracts are characteristic for the markets. These long-term contracts will, however, cancel the principal cost-efficiencies claimed for GC markets. In the case that low-fixed-cost technologies have high market share inside GC market, long term contrast will not take place and the low-cost technologies will inefficiently drive high fixed-cost technologies out of the green certificate market, because of the over-investment risk that would drop the certificate prices.	Effectiveness, Cost-efficiency, Lack of Bias, Effects on Economy, & Functionality in Market Environment
(Lesser, Su 2008)	Neutral	Feed-in tariff development	Author introduces two part feed-in tariff system that includes auctioneered subsidy payments that are adjusted with capacity efficiency and market price. This would help feed-in tariff with efficiency and price transparency.	All except Rent-seeking & Harmonisation Qualities

(Lipp 2007)	Feed-in tariff	Feed-in tariff versus green certificates	Denmark, Germany, and United Kingdom case study shows that feed-in tariff seems to outperform green certificate in effectiveness as well as in cost-efficiency.	Effectiveness, Cost-efficiency, Lack of Bias, Equity and Fairness, Effects on Economy, Production Neutrality & Technology Maturity Neutrality
(Menanteau, Finon et al. 2003)	Neutral	Quota versus price instruments	The great efficiency of feed-in tariff mechanisms to achieve renewable energy development targets is confirmed by the gradual disappearance of competitive bidding systems in the wake of low project implementation rates. However, the possible superiority especially in cost-efficiency of green certificate will be left to be proved when empirical results arrive from implemented systems.	All except Rent-seeking, Decision-making Feedback & Ease of Control
(Midttun, Gautesen 2007)	Neutral	Innovation product life-cycle and technology maturity as a starting point for multi-policy implementation.	Feed-in tariff and green certificate system should not be seen as competing alternatives, but rather as complementary regulatory instruments targeting subsequent steps in the product cycle.	Cost-efficiency, Equity and Fairness, Production Neutrality & Technology Maturity Neutrality
(Mitchell, Bauknecht et al. 2006)	Feed-in tariff	Different risk rates between feed-in tariff and green certificates	Even though the prices available within the United Kingdom's green certificate system are similar to those available under the wind tariff of the German feed-in tariff, the green certificate is much more ineffective because it creates less attractive conditions for investors that stem from its price, volume and balance risk.	Effectiveness, Cost-efficiency, Investor's Predictability, Production Neutrality & Technology Maturity Neutrality
(Rickerson, Grace 2007)	Feed-in tariff/ hybrid	Feed-in tariff	Rather than focusing on the weaknesses of green certificates (GC) as designed and implemented in Europe, it may be more helpful for U.S. states to focus on the strengths of feed-in tariffs (FIT), and on how elements of FIT could be synergistically integrated into the U.S. framework. This might mean introducing fixed-price elements into existing GC policies or designing new FITs or GC/fixed-price hybrids for states that now lack policies to support renewables.	All except Rent-seeking, Author's Predictability & Harmonisation Qualities

(Toke 2007)	Feed-in tariff	German feed-in tariff versus the United Kingdom renewable obligation (green certificate)	Author points out that the United Kingdom renewable obligation (UK green certificate) is not more cost-effective than German feed-in tariff. This argument is based on empirical data using capacity factor as a multiplier when subsidy amounts are calculated.	Effectiveness, Cost-efficiency, Lack of Bias, Equity and Fairness, Effects on Economy, Functionality in Market Environment & Harmonisation Qualities
(Chen, Wiser et al. 2009)*				
(del Río 2008b)*				
(Dinica 2006)*				
(Enzensberger, Wietschel et al. 2002)*				
(Fouquet, Johansson 2008)*				
(Langniß et al. 2009)				
(Lauber 2004)*				
(Ringel 2006)*				
* Additional material that was found but not included in the analysis				

One of the most cited academic studies about renewable energy generation policy instruments is Menanteau, Finon et al. (2003). In this study the authors highlight the great efficiency of feed-in tariffs in achieving renewable energy development targets, which is confirmed by the gradual disappearance of competitive bidding systems in the wake of low project implementation rates. However, they emphasise also that green certificates might threaten the triumphal march of feed-in tariffs in the future. The possible theoretical superiority of green certificates, especially in cost-efficiency, was left to be proved when empirical results arrive from systems where they have been implemented for some time (Menanteau, Finon et al. 2003).

A few years later, in 2005, the Commission of the European Communities released its report comparing the effectiveness and cost-efficiency of different policies. The report's main point was that green certificate policies implemented in Europe were, in general, less effective and cost-efficient than feed-in tariffs (Commission of the European Communities 2005). These kinds of results have been highlighted as well in recent studies. The studies have been mostly comparing German and Spanish feed-in tariffs and the United Kingdom's green certificate systems, especially from the wind power viewpoint (Mitchell, Bauknecht et al. 2006, Lipp 2007, Toke 2007, Butler, Neuhoff 2008). Figure 19 presents the effectiveness rates from the wind power perspective and as it can be seen the German and Spanish schemes have boosted tenfold bigger capacity than the British scheme.

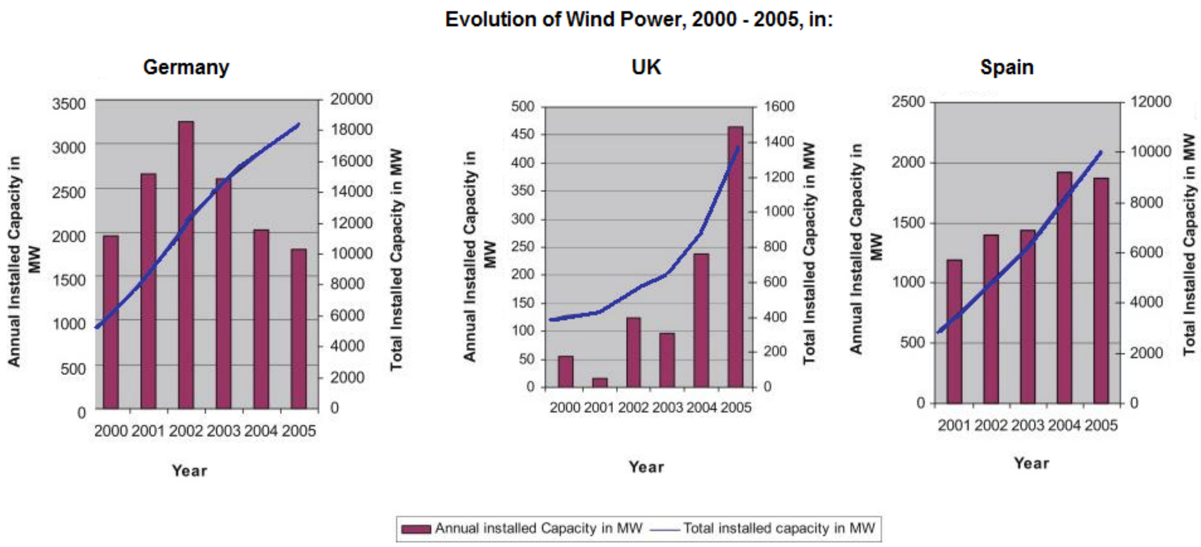

Figure 19: Effectiveness Figures of Germany Spain and UK. Source: (Stenzel, Frenzel 2008)

Figure 20, on the other hand, describes the expected subsidies for wind power per kWh. As we can see from the figure, with the scenario[48] that Butler and Neuhoff (2007) have selected, the average subsidy per kWh paid for wind projects over a 20-year project lifetime for a project build in a given year is higher under the British green certificate scheme until year 2017 than under the German feed-in tariff scheme.

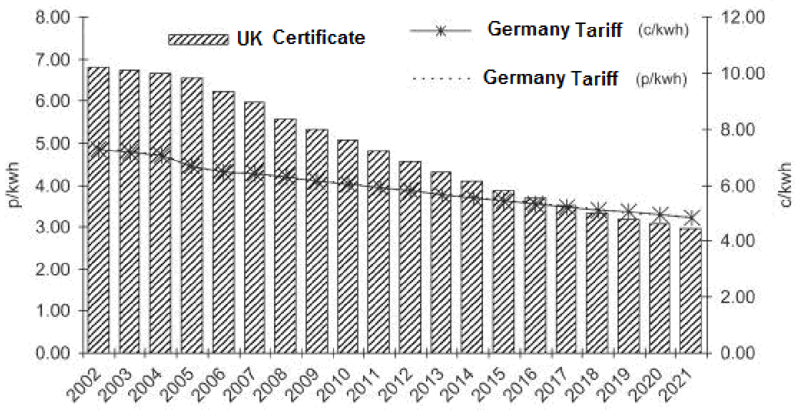

Figure 20: Expected Average Wind Power Subsidy under the German and British Policy Instrument. Source: (Butler, Neuhoff 2008)

[48] More about starting values, assumptions detailed data about the German and British policy instruments are available (Butler, Neuhoff 2008)

Similar results are delivered in the other empirical studies as well. Year 2004 average to maximum support levels for wind power in Germany were from 70 €/MWh to 105 €/MWh, and in the UK from 110 to 120 €/MWh (Lipp 2007). These results and estimations have been something of a surprise, because it has been strongly argued that the guaranteed prices with feed-in tariffs do not encourage competition and therefore renewable power would not be generated at the lowest possible price. On the other hand, this kind of competition is inherited in a green certificate scheme (Lipp 2007). Nevertheless, as seen above German and Spanish feed-in tariff schemes have been outperforming the United Kingdom's green certificate (renewable obligation) scheme and similar systems in Belgium and Italy in the cost per new electricity produced. However, it has to be emphasised that the huge effectiveness of feed-in tariff has made the total cost of the scheme higher (Lipp 2007, Green Stream Network 2007, Toke, Lauber 2008).

The impact policy has on investor's risk is one of the primary reasons that have been offered as an explanation in Europe for feed-in tariffs' superiority in effectiveness (see Figure 19) and efficiency in cost-per-new-capacity-produced (see Figure 20). In contrast to the fixed prices of feed-in tariffs, the price as well as the volume risk connected to a green certificate scheme can raise the cost of capital used in financing the new renewable investments, and can therefore increase the total costs of a green certificate scheme (Commission of the European Communities 2005, Mitchell, Bauknecht et al. 2006, Rickerson, Grace 2007, Toke 2008, Kildegaard 2008).

Another reason for the flat performance of green certificates in the field of cost-efficiency could be that the long-term power purchase contracts that have been used under the scheme have hindered the efficiency gains (Haas, Eichhammer et al. 2004). Even though feed-in tariffs do not boost price competition between renewable energy generators and electricity suppliers, there will be competition between renewable energy generation plant manufacturers, and, for example in the case of wind energy, over the best locations (Haas, Eichhammer et al. 2004, Butler, Neuhoff 2008). However, as Figure 21 shows, wind producers friendly feed-in tariffs have enabled the building of wind power sites in places where wind conditions are not optimal. For example even though Germany has one of the Europe's worst wind conditions, it has the biggest installed capacity in Europe. It has been the same way especially with the solar power in Germany.

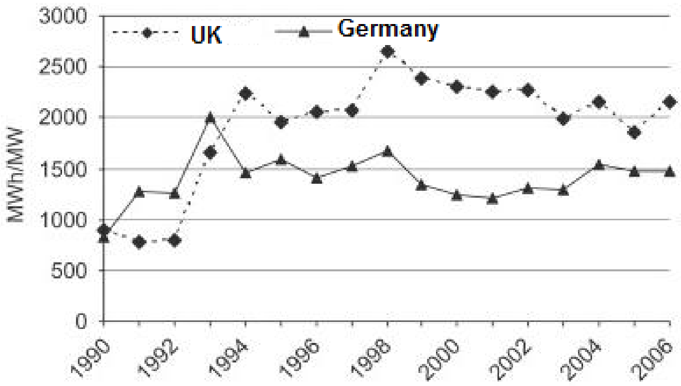

Figure 21: Wind Power Generation from Installed Capacity. Source: (Butler, Neuhoff 2008)

This is seen as an advantage from a diversity point of view, but also as leading to highly inefficient investments (Toke 2008, Butler, Neuhoff 2008). Figure 21 describes the level of generation per unit of installed capacity MW in UK and Germany between 1990 and 2006. Low figures at the beginning of 1990 in UK were mostly because of low turbine ratings at experimental sites. In Germany after 1993, the rate has been falling because developers have used less windy sites that lucrative subsidies have made possible (Butler, Neuhoff 2008).

By contrast with the United Kingdom green certificate scheme's ineffective performance, in the United States - especially in Texas - there have been very positive experiences of green certificate instrument use. However, it has been argued that in the Texas case, the low targets and overall tax incentives have had more to do with meeting the targets than the green certificate instrument itself (Wiser, Bolinger et al. 2007, Chen, Wiser et. al 2009). At the same time, it should be remembered that there have likewise been other policy incentives boosting the effectiveness of the feed-in tariff scheme for example in Germany. These have included investment grants, grid connection policies, and research and development incentives among others (Green Stream Network 2007).

From an equity and fairness viewpoint, feed-in tariffs have helped small players take a part in the renewable energy generation market, while the green certificate scheme has seemed to forward the big players' advantage, mostly because they can handle the risk better (Lipp 2007, Toke 2007). This characteristic of the green certificate scheme has been seen as diminishing competition (Toke, Lauber 2007). Supporting small companies and individuals is, in fact, a good way to allocate wealth as long as cost-efficiency does not suffer noticeably (Toke 2007). However, there have been arguments that even though the feed-in tariff might work well in the short run, from the cost-efficiency viewpoint this might end up causing troubles in the longer term because of the growing cost originating from an instrument's possible over-effectiveness, static structure, and the instrument's tendency to distort markets (Green Stream Network 2007).

The feed-in tariff schemes' guaranteed prices are set for long time-periods, thus new acquired knowledge or a new cost structure will not correct those prices. Green certificate prices on the other hand will reflect the production cost changes and therefore according to some studies GC is seen to be more dynamically efficient and this way more flexible than the feed-in tariff (Green Stream Network 2007). However, Toke (2007) and many other academics argue that because feed-in tariffs are seen to promote the innovation in renewable energy technology better than green certificates they can be seen to be more dynamically efficient than green certificates. This is partly because the "overall" money earned could be used to invest in research and development and because the effectiveness of an instrument has an endogenous effect of speeding up the learning process and cost reductions of different technologies (Finon, Perez 2007, del Rio, Gual 2007). Hence the static quality of the feed-in tariff might become an advantage in terms of dynamic efficiency. However, there is not much solid research done how much new innovations can be pinpointed to be caused by feed-in tariff. Either way, guaranteed prices with feed-in tariffs and locking the quota with green certificates will cause inflexibility. Thus, neither fundamental feed-in tariff nor green certificate schemes are naturally flexible, that is they do not automatically correct start values under new knowledge, and thus they need adjustment if this kind of flexibility is required.

With our two renewable energy policy instruments, rent-seeking is more focused on the time before policy instrument implementation. Companies are lobbying for the one instrument that is seen to suit their purposes in the best way. However, green certificates are seen as superior from the rent-seeking perspective, because with the feed-in tariff policymakers fumble with the problem of how to get truthful information from the industry without auction or market, since it is to the industries' advantage if the subsidy prices are set high. Hence they might be prone to exaggerate the investment and production cost, if asked for figures (Lesser, Su 2008).

Investor's predictability is seen to be feed-in tariffs' biggest asset compared to green certificates and the major reason for its high effectiveness (Commission of the European Communities 2005, Mitchell, Bauknecht et al. 2006, Rickerson, Grace 2007, Lipp 2007). From the authors' point of view the fundamental green certificate and feed-in tariff are in the same line, because in reality when setting the quota very high the price will rise high and vice versa. Because both mechanisms are more often than not funded by the authority, they will not have a direct effect on government's monetary base. However, because the indirect effects might be radical, a flex-mechanism might be preferred, as it has been for example in the United Kingdom - where a "safety valve" penalty price is set - or in Spain, where there is an upper limit for subsidised renewable energy under the feed-in tariff (Green Stream Network 2007).

In the case of the green certificate or the feed-in tariff, decision-making feedback is not as clear as for example in the case of investment grants. This is mainly because the scheme costs are postponed outside of the government budget. For this reason, the total cost and effects of the instrument are not always that easy to spot. Nevertheless, the green certificate gives an easily understandable price and the feed-in tariff will make clear the utility of the selected price by effectiveness. However, because of the inflexibility of the fundamental instruments, correction is not that simple. In addition, inefficiencies or high price might not be simply the fault of the instrument, but the lack of proper implementation (Green Stream Network 2007).

Feed-in tariffs require policymakers to define payments for individual technologies (e.g., wind, solar, geothermal), payment structures (e.g., fixed or declining), and payment duration. *"All three attributes can require significant "guesswork" on the part of policymakers as to future market conditions and rates of technological improvements"* (Lesser, Su 2008). With green certificates this "guesswork" is left at least partly for markets to handle, and the hard part is to select the optimal amount of renewable energy to promote. This optimal amount is, for example in the European case, already given by the directive. *"Essentially, traditional feed-in tariffs designs require government policymakers to substitute their judgment for that of markets in the selection of long-term technological "winners and losers." However, long-term forecasting is notoriously imprecise and inaccurate, given the multitude of uncertainties that affect the future. Moreover, once specific price paths (i.e., level, structure, and duration) are specified, changing those paths is both difficult and costly, as it creates* *excessive regulatory uncertainty that, in turn, increases investment costs"* (Lesser, Su 2008).

However, even though the "guesswork" is relatively resource-consuming after implementation, the feed-in tariff needs relatively little monitoring and supervision. The green certificate scheme, on the other hand, needs quite a lot of preparation work, as well as monitoring and other control after the implementation. This is because there are more actors and transactions involved (Green Stream Network 2007). This has resulted in green certificate schemes having had higher administrative costs than feed-in tariff schemes (Toke, Lauber 2008).

Functionality in a market environment is seen to be one of the green certificates' advantages. Feed-in tariffs distort the market by taking the renewable energy generation out of the market competition. There are ways to modify the feed-in tariff so that it functions better with the market environment. For example, the Spanish premium scheme will expose renewable energy generation to market competition (Green Stream Network 2007, del Rio, Gual 2007). However, Carlén (2006) argues that if future electricity price is highly uncertain, a feed-in tariff based on premium is likely to be an inferior instrument compared with a green certificate or guaranteed price feed-in tariff scheme, at least from an efficiency standpoint.

Harmonisation qualities and connectability are discussed further in the next sub-chapters. Production neutrality, letting the market decide and therefore not picking the winners, is why the green certificate is preferred and yet on the other hand criticised. However, green certificates can be modified just as well as feed-in tariffs to offer a different amount of subsidy for different technologies, for example by granting more than one certificate for more immature technologies (Green Stream Network 2007). Different price levels for different technologies at different maturity stages is nevertheless more often associated with the feed-in tariff schemes. It is argued to be fair and in some other instances to be dangerous because resources, money, and effort are used for technologies that might gradually develop with time, not with force (Lesser, Su 2008). This dilemma is discussed more thoroughly in the last sub-chapter.

As a conclusion, for the feed-in tariff versus green certificate debate, the superiority of the instrument is greatly dependent on which criterion is emphasised. It has to be remembered that whichever instrument is chosen, the success of the instrument is mostly attributable to how well it is implemented (Butler, Neuhoff 2008, Arasto 2006, Green Stream Network 2007, Haas, Eichhammer et al. 2004). Both instruments can be modified to look like each other and these modified ones might function much better than the basic or fundamental ones (Green Stream Network 2007). In addition, good qualities of other support instruments could be connected to these instruments to make them function even better (Lesser, Su 2008, Haas, Eichhammer et al. 2004). Because of the limits of the real world, one always has to make some compromises with the criteria and targets since, at the end of the day, it is the consumer who pays the bill. Hence after criteria weights are decided, whichever instrument or a mix of instruments gives the smallest cost for the consumer should be selected (Haas, Eichhammer et al. 2004).

7.3 Harmonization of Renewable Energy Generation Policy Instruments in EU Scope

"…it is too early to compare the advantages and disadvantages of well-established support mechanisms with systems with a rather short history. Therefore, and considering all the analyses in this Communication, the Commission does not regard it appropriate to present at this stage a harmonised European system" (Commission of the European Communities 2005). This conclusion, and especially a few other earlier ones made by the Commission of the European Communities, meant at least a short break for those discussions that were steering the European Union towards a harmonised policy instrument for renewable energy. For those who believed in feed-in tariff superiority, these decisions were a relief, but for those who had changed their policy depending on the former signals from Brussels, it made for quite a headache. For example, Denmark had terminated its feed-in tariff and had finalised its plans for a green certificate scheme. But after the Commission stated in May 2002 that the feed-in tariff did not constitute state-aid, it took the Danish government only a month to bury its plans for the certificate scheme (Angnolucci 2008).

Harmonised support systems have almost solely focused on quota systems with EU-wide tradable green certificates (Söderholm 2008). However, there have been a few academic comments about implementing a harmonised feed-in tariff scheme as well (Muñoz, Oschmann et al. 2007).

Harmonisation, if implemented, has been seen to drive huge efficiency gains and thus help the European Union to gain momentum in meeting the renewable energy generation targets in the most cost efficient way (Söderholm 2008). However, in addition to the competition between national instrument preferences, the problems with national advantages and national CO2 limits have been at least partly in the way of harmonisation. The pros and cons of harmonisation have been analysed in several studies, and the studies selected for comparison in this thesis are presented below.

Table 10: Selected Appraised Authors - Their Main Focus and Results (Continues next page)

Author	Main focus	Main result for sub-chapter's issue
(Haas, Eichhammer et al. 2004)	Renewable energy technology's successful and effective promotion	With a given target of a certain amount of renewable energy (RE) at a certain time, neoclassical economic theory predicts that a European Union-wide quota exclusively for new RE installations with an accompanying international trading scheme would be the most efficient approach in terms of minimising additional costs. For European-wide trade of certificates with maximum efficiency gains, an EU-wide harmonisation is undoubtedly necessary for a European RE quota. Currently, however, it appears unlikely that such a harmonised strategy will be implemented in the short-term because certificates will not contribute to national CO_2-reduction unless it is closely co-ordinated with an emission quota-system, and even then it is the emission quota which gives the CO_2-reduction. Secondly, the value of CO_2-reduction will not be included in the price of green certificate (GC). Hence the only reason to track GC is to enforce the development of sustainable long-term technologies. Thirdly, at present the GC-systems introduced in the EU are very different.
(Muñoz, Oschmann et al. 2007)	Feed-in tariff model that could be harmonized in the European Union	Feed-in tariffs (FIT) are an effective and cost-efficient way to increase the generation of renewable energy and achieve RE targets. FITs are compatible with European Union state-aid, competition rules, and commensurability, and compatible with a liberalized electricity market. Harmonization of FIT that would include national as well as EU-wide adjustment factors would provide long-term market stability and flexibility and promote technology innovation.
(Söderholm 2008a)	Renewable energy policy harmonisation in the European Union. Critical analysis of the paper by Muñoz et al. (2007)	Paper argues that there exists a strong case for disregarding national benefits of renewable energy (RE) production in the design of a harmonised policy instrument. Among other things, local deployment schemes would be most effectively handled with direct policies, not with RE policy instruments. Article stresses the "one policy one goal" basic idea. If national benefits are stressed it might be more convenient to stay with national support schemes. One of the most important factors when choosing the policy instrument between the quota- and price-based instrument is the steepness of the marginal benefit and marginal cost curve. This point was argued to be overlooked by Muñoz et al. 2007.

(Söderholm 2008b)	Harmonisation of green certificates market	Söderholm concludes that the EU-wide support scheme is unlikely to take place in the near future, but evolution towards a more harmonised green electricity support scheme might start when a few countries take the lead and introduce either bilateral or multilateral joint support schemes. This support scheme has the potential for achieving goals like energy security, a more diversified production portfolio, and reduced environmental degradation more cost-effectively than a national one. To achieve these goals, participating countries have to put lots of effort into designing common game rules so that they will not hamper the cost-efficiency, for example with colliding subsidies. Politically sensitive issues like local employment might work as a barrier that has to be crossed to win public approval.
(Toke 2008)	A critical survey of the view of the new EU-wide green certificate harmonisation proposal called guarantees of origin	Toke objects that there is plausible possibility that the proposed EU-wide renewable target - 20 % of the energy has to be produced by renewables by the year 2020 - would not be achieved cost-effectively. Thus proposed trading by linking together national support systems by guarantees of origin, or in other words green certificates and trading with national surplus, might cause very high certificate prices and price volatility - mostly because of great under-supply of certificates. This would yield high money transfers from one member-state to another and thus cause undermining of national support systems. Trade with guarantees of origin may strongly disadvantage independent renewable operators and give extra returns to major electricity companies.
(Toke 2008)	The down sides of green certificate harmonisation	Here Toke sees that the real problems would begin if the green certificate- based system is harmonised European Union-wide. A harmonised system would allocate investment weight more to major investors and in this way expel local small scale investors, which would in turn most probably, especially in Germany and in The Netherlands, reduce renewable investment figures. Local investment is seen as important among others because it may increase local social and environmental benefits and reduce planning as well as implementation opposition.
(Verhaegen, Meeus et al. 2007)	The advantages and challenges of harmonisation of green certificates system	EU-wide harmonised renewable energy support system would have a few advantages compared to member-state independent ones. Harmonisation of green certificate (GC) system would result in more stable prices and higher cost-effectiveness. However, this kind of harmonised system could be subverted by production targets per member-state, preventing the market from functioning in a cost-effective manner. Furthermore, while integrating existing different GC systems, any remaining differences should be carefully considered. How hard the possible integration would be is illustrated by the case of Belgium, where four different systems are in place nowadays. If the integration seems to be hard even inside one member-state, it is very likely that harmonising it EU-wide would present a serious challenge and possible implementation would be still far in the future.
(del Río 2005)*		
(Morthorst, Jensen 2007)*		
(Nielsen 2002)*		
(Unger, Ahlgren 2005)*		
* Additional material that was found but not included in the analysis		

European-wide harmonisation of renewable energy generation policy is seen to boost cost-efficiency and especially static cost-efficiency (Verhaegen, Meeus et al. 2007). For example, various analyses show that already a common Nordic green certificate market could save around 0.5 billion euros in contrast to all four Nordic countries operating separately with renewable electricity targets (Rydén 2006). However, some academics are afraid that it might lead to picking so-called “low hanging fruits”. Potential immature technologies might not be invested in and thus might never have a chance to get onto the “shelf”. Hence the dynamic efficiency might suffer (Verhaegen, Meeus et al. 2007).

Among the key problems in the way of harmonisation are the national benefits and national renewable targets. It has been seen that harmonisation might steal these national benefits and that consumers in some countries might end up paying for renewable energy projects that take place in other countries and thus “only benefit those countries” (Toke 2008).

One of the major requirements for the implementation of harmonised Europe-wide renewable energy policy instruments is that the electricity markets are fairly well integrated (Söderholm 2008a). This kind of integration has already taken place in the Nordic countries. Other European countries have been opening the regulated markets and the direction is more and more towards integration. However, the guaranteed timetable to even fairly smooth-running EU-wide electricity markets is still a question-mark. There is a good deal of faith that this will happen, but owing to the current market situation it just might take a bit more time.

In the presence of an integrated electricity market, it should be obvious that benefits of green electricity promotion will not be at risk of disappearance if the certificate market is integrated. This is because any capacity addition in, say Norway, lessens the need for conventional capacity expansion in for example Finland. On the contrary, in a way the country where the new green production is implemented is the one that has to bear the negative environmental effects of new green production that comes along with the plant implementation (Söderholm 2008b). The issue is not of course quite this black and white. There are positive impacts as well, such as employment and industry emergence when renewable investments are made (Muñoz, Oschmann et al. 2007).

However, it is highly uncertain that energy policies would be an effective and particularly efficient way of reducing unemployment or boosting industry. *“Moreover, it is hard to see why renewable electricity should be subsidised on these grounds; a multitude of measures can spur local employment including investment in fossil-fuelled power plants.”* The best way might be to use one policy instrument for one policy goal.

From an EU perspective, this primary goal is the specific target for renewable energy (Söderholm 2008a).

One rather justified worry concerning harmonisation is that it might place investment weight more on major investors and in this way shut out local small-scale investors. Local investments are seen as important, because they may both increase local social and environmental benefits, as well as reducing planning and implementation opposition (Toke 2008). The interaction with emission trading is seen as problematic as well. This will be studied more closely in the next sub-chapter (Haas 2004, Morhorst 2001).

As a conclusion, it is unlikely that we will witness a harmonised EU-wide support scheme in the foreseeable future (Haas, Eichhammer et al. 2004, Söderholm 2008b, Verhaegen, Meeus et al. 2007). The possible implementation of a harmonised system will constitute a huge challenge, regardless of which support system is chosen (Söderholm 2008a). Especially national green certificate schemes are highly differentiated and at this moment national schemes are seen to be diverging rather than becoming harmonised (Haas, Eichhammer et al. 2004). For example, in the case of Belgium it has appeared to be an insuperable problem to integrate four different national green certificate systems, something that should be easy compared with EU-wide harmonisation (Verhaegen, Meeus et al. 2007). However, when electricity markets move towards harmonisation, this subject might gather momentum once again. In the discussion of harmonisation, it would be important that price instruments like feed-in tariffs should be seriously considered as well, not least because arguments against the feed-in tariff lack empirical evidence (Söderholm 2008a, Muñoz, Oschmann et al. 2007).

7.4 Interaction between Emission Trade and Green Certificate or Feed-in Tariff

Climate policy is implemented to mitigate greenhouse gas emissions. The implementation of renewable energy generation instruments is partly justified because they should help in this task. However, from a “one goal, one policy” perspective, European directives for renewable energy generation are narrowing inefficiently the national space to meet emission mitigation targets, because they lock the ways with which to mitigate emissions. However, they might still be needed because although effective in the short-term, the emission trade might lead to weak long-term efficiency by blocking currently expensive but potentially useful mitigation technologies (del Río 2008a). One example is that a tax as high as 272.5 \$/ton carbon dioxide (1000 \$/ton carbon) would increase the price of coal power by about 200 \$/MWh, which is less than half of the price of current solar photovoltaic energy (Sandén, Azar 2005). On the other hand, renewable energy promotion systems would not on their own function most effectively as an emission reduction instrument (Morthorst 2003b). Thus to achieve optimal intertemporal efficiency in emissions abatement, a wise policy combination between technology-oriented and technology-neutral policies might be needed (del Río 2008a).

In multi-policy situations, some compromises have to be made. This sub-chapter does not try to go deeply into this important and complicated optimisation challenge, but briefly to explain the interaction between emission trade, the green certificate, and the feed-in tariff, which are the most popular primary renewable energy generation instruments at this moment. An interesting future study would be to have a wider examination of this scope by adding different modifications of the above-mentioned instruments, in addition to other instruments, and to analyse especially the carbon tax and hybrid instruments for both climate policy and renewable energy generation.

As hinted above, in the short-run the cost of achieving a given emission level called for in the emission trade is likely to be higher with renewable energy policy instrument schemes than without (Harrison, Sorrell et al. 2005). In particular the feed-in tariff scheme might increase the uncertainty of an emission allowance price, because the level of renewable energy implementation is unknown. The green certificate's dynamic nature adjusts this with the emission trade and thus this will not cause as radical an effect (Green Stream Network 2007).

One important notion is that even though renewable policy instruments might boost the dynamic efficiency of emission mitigation, it should be remembered that the green certificates or the feed-in tariff schemes do not contribute any additional carbon dioxide reductions in a given compliance emission trade period, if emissions are fixed by the cap. Emission savings made in the electricity sector will be used in some other sector (Harrison, Sorrell et al. 2005).

The feed-in tariffs cannot be smoothly integrated with emission trade. However, possible integration with carbon tax might be worth further examination. With the green certificate scheme, there have been ideas that the certificates/allowances of various trading schemes could be made recoverable across schemes. Such recoverability has in a way already been implemented, for example in the European emission scheme through the Linking Directive, which makes Joint Implementation (JI) and Clean Development Project (CDM) credits valid for compliance. It has been suggested that trading could be allowed between the emission trade and green certificate schemes in EU member-states. Such a proposal would allow companies to use the emission reduction implicit in a green certificate for EU emission trade scheme compliance (Harrison, Sorrell et al. 2005). However, the problems of double counting of emission reductions and lack of common approval within the EU might shelve this idea from the foreseeable future.

When we scrutinize this interaction from a renewable energy perspective, already the emission trade on its own increases the competitiveness of renewable energy generation. This means that a given amount of renewable generation can be achieved with less support from renewable energy generation instruments, which has a direct impact on the market for green certificates. For any given renewable quota there is a difference between the marginal cost of renewable production and the marginal revenue available from the wholesale electricity price. Because emission trade raises the wholesale electricity price, it thereby decreases the cost-gap for a given renewable quota. With a competitive green certificate market, certificate prices should also decrease, automatically adjusting to the lower level of support required. In normal circumstances, the price of emission trade allowances and the price of green certificates are therefore negatively correlated. Thus, a sufficiently high allowance price could promote enough green generation to meet the green certificate quota, in which case the certificate price would fall to zero. This interaction thereby results in a smaller cost of the green certificate scheme (Harrison, Sorrell et al. 2005). From a feed-in tariff perspective, emission trade raises electricity prices, and tariff prices do not change except in premium cases, thus even in this instance the cost of renewable support scheme declines. Hence the feed-in tariff premium could be seen to work in the worst way with emission trade.

As a conclusion, climate policy and renewable energy generation policy instruments should not be seen as substitutes but as complements to each other. Even though they may have similar goals, we have to remember that they also have different goals. However, because they have strong interactions and effects on each other's functioning and targets, it is important that when either of them is implemented, these interactions are emphasised, examined, and understood. Table 11 introduces valuable studies about the subject that could further deepen this analysis.

Table 11: Additional Material That Was Found but Not Included in the Analysis

(Blanco, Rodrigues 2008)
(de Vos 2004)
(del Río, Hernández et al. 2005)
(Kara, Syri et al. 2008)
(Unger, Ahlgren 2005)
(Van Horn, Remedios 2008)

7.5 The Influence of Renewable Energy Generation Policy Instruments on Electricity Prices

It always costs money to build subsidy schemes, and that money has to come from somewhere. In the case of renewable energy generation, it is either taken from government, customers or the pockets of the producers of conventional energy generation. Most often the subsidies are paid by the consumers in their electricity bill, which means it is built into the retail price (Haas, Eichhammer et al. 2004). Especially in countries like Germany, Spain, and Denmark where a significant amount of renewable power generation has been implemented under support schemes, there has been growing concern over the increasing financial burden for electricity consumers caused by them (Sáenz de Miera, del Río et al. 2008). However, more recently there have also been arguments that renewable energy generation policy instruments might have totally opposite direct and indirect effects on electricity prices. Instead of raising retail prices, renewable energy support schemes might end up actually lowering them. Even though this is an important issue - especially from a popularity perspective for renewable energy generation policy instruments - the empirical literature on the interactions between renewable energy policy instruments and the electricity market is surprisingly thin (Sáenz de Miera, del Río et al. 2008). This sub-chapter shortly presents the academic debate found about this issue.

Table 12: Selected Appraised Authors - Their Main Focus, Key Argument, Data Set, and Results

Author	Data set	Instrument effect on:		Main result for sub-chapter's issue
		Wholesale Prices	**Retail Prices**	
(Chen, Wiser et al. 2009)	US Renewable Portfolio Standard (2003)	Negative or Positive	Negative or Positive	Studies made in US about direct cost impacts of Renewable Portfolio Standard mostly give low impact values. Among authors' sample-studies the median increase in retail electricity rates was 0.8 %. Largest estimated decrease impact was 5.2% and highest increase estimate was 8.8%.
(Bode 2006)	Theory	Negative	Negative or Positive	Feed-in tariff mark-up increases the power costs. However, owing to the merit order effect, feed-in tariff lowers the wholesale price. Therefore the market equilibrium changes. The net effect of these three variables might cause either positive or negative change in retail price, depending on the structure of the market.
(Böhme, Dürrschmidt 2008)	Germany feed-in tariff (2007)	Negative	Negative or Positive	Even though the German feed-in tariff scheme costs have been rising every year, it can be argued that already the merit order effect, which exerts downward pressure on the wholesale electricity market, might have caused that retail prices are lower than without the scheme. If the analysed savings in external cost are included, the scheme has been extremely economical.
(Rathmann 2007)	Germany (2005-2007)	Negative	Negative	Renewable electricity promotion instruments can reduce indirectly EU emission trade-driven electricity prices by lowering the amount of emissions caused by power production. The effect is weakened if allocation is done ex-post based on a benchmark, and it would cease to exist when emission reductions due to renewable electricity are correctly anticipated. In the German case, the feed-in tariff scheme has reduced the wholesale prices in 2005-2007 by 6.4€/MWh and retail prices by 2.6€/MWh.
(Sáenz de Miera, del Río et al. 2008)	Spain feed-in tariff	Negative	Negative or Positive	In the case of Spanish wind electricity promotion, it can be shown that there is an absolute negative correlation between wholesale price and renewable energy promotion. Because of this, the renewable promotion scheme cost may be offset by the reduction in wholesale price, thus leading to reduction of retail prices.
(Wiser, Namovicz et al. 2007)	US Renewable Portfolio Standard (2003)	Negative or Positive	Negative or Positive	To date, it is reasonably clear that cost impacts of Renewable Portfolio Standards (RPS) - that is the US green certificate scheme - have varied substantially by state. However, there is little evidence of sizeable impact on average electricity retail prices. In quite a few instances it not certain whether RPS is leading to higher or lower retail electricity prices, but lower prices are certainly possible.

(Unger, Ahlgren 2005)*
(Harrison, Sorrell et al. 2005)
* Additional material that was found but not included in the analysis

The consumer costs, from here on retail prices, are the result of combining the wholesale price with the renewable power generation support price (Sáenz de Miera, del Río et al. 2008). In addition, retail prices include distribution and other service costs as well, which might be affected by increasing the share of renewable energy, but they are left outside this analysis. Therefore, the additional burden for consumers could be calculated for example in the case of feed-in tariff with the formula:

*Renewable power generation support cost = [Support Quota * (Average support fee – wholesale market price) + Transaction costs]/ Total Power Generation* (3)

And with the case of the green certificates with formula:

*Renewable power generation support cost = [Support Quota * Average certificate price + Transaction costs]/ Total Power Generation* (4)

Table 13 presents additional costs accruing from German feed-in tariff schemes.

Table 13: German Feed-in Tariff Scheme Cost Figures. Source: (Böhme, Dürrschmidt 2008)

	Feed-in Tariff Scheme Cost	Addition to the Electricity Price
Year	Billion Euro	Cent/kWh
2000	1,0	0.2
2001	1,2	0.3
2002	1,8	0.4
2003	1,9	0.4
2004	2,5	0.6
2005	2,8	0.6
2006	3,3	0.8
2007	4,3	1.0

Here the wholesale market price, or as presented by Böhme and Dürrschmidt (2008) the value of conventionally-produced electricity that is substituted by supported electricity, is estimated to be 5 cents/ kWh (EUR 0.05/kWh). In Germany, for example in the year 2007, the supported quota was 67 TWh and the average support fee was 11.4 cents/kWh. Therefore, the support cost is approximately 4.3 billion Euros according to the indicator of Formula (3)[49]. This raises the retail electricity prices by 1.0

[49] Transaction cost are excluded

Cents/kWh[50]. This is not an insignificant figure. It is 20% of the used wholesale electricity price.

However, the impact of a renewable energy generation policy instrument may be much more ambiguous than this (Sáenz de Miera, del Río et al. 2008). This is because increasing the amount of renewable electricity has direct and indirect downward effects on electricity price as well. Direct downward effects are caused by the fact that renewable power generation often has a lower variable cost than conventional power generation (Sáenz de Miera, del Río et al. 2008). This, then again, is because renewable power generation normally has lower fuel, operating, and maintenance costs[51] (Wiser, Namovicz et al. 2007). If conventional energy plants - which are usually the marginal generation plants and thus the ones setting the wholesale electricity price - are substituted by the renewable electricity plants, the wholesale electricity price would be reduced (Sáenz de Miera, del Río et al. 2008, Bode 2006). In other words, as Böhme and Dürrschmidt (2008) have clearly put it: *"The market price of electricity is determined by the most expensive power station still needed to satisfy the demand for electricity (merit order)."* This is neatly demonstrated with the simplified Figures 22 and 23, which illustrate the electricity price formation in an imaginary wholesale power market and the effect caused by boosting low marginal cost renewable energy.

[50] Gross electricity consumption in Germany was 617.5 TWh in 2007. However, because industry was exempt from feed-in tariff cost the additional consumer cost, that is the retail price was higher than 4.3 billion Euros/ 617.5 TWh that would have given 0.7 cents/kWh implemented to formula (3).

[51] However, the effect would not be similar in cases if the new renewable would be for example bio power, which has a relatively higher marginal cost than for example wind or even combined heat and power production (CHP) with coal or gas. Therefore, the direct effect would not be similar to what is presented here.

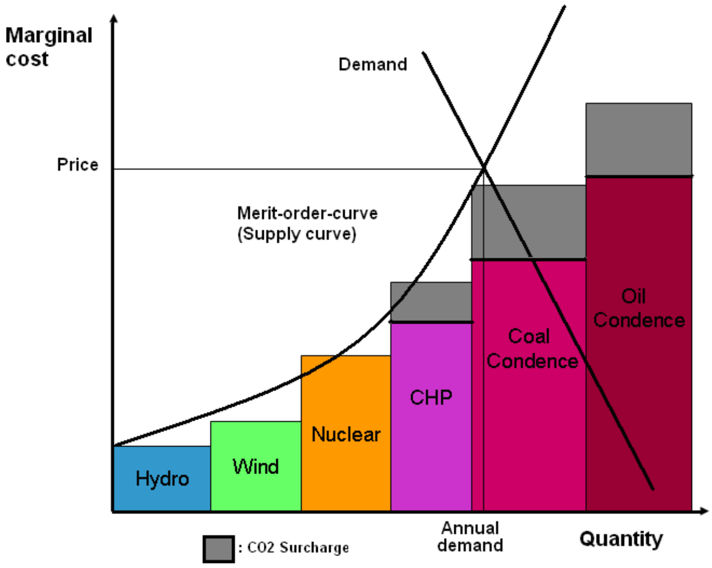

Figure 22: Imaginary Electricity Price Formation in the Short-term Wholesale Power Market

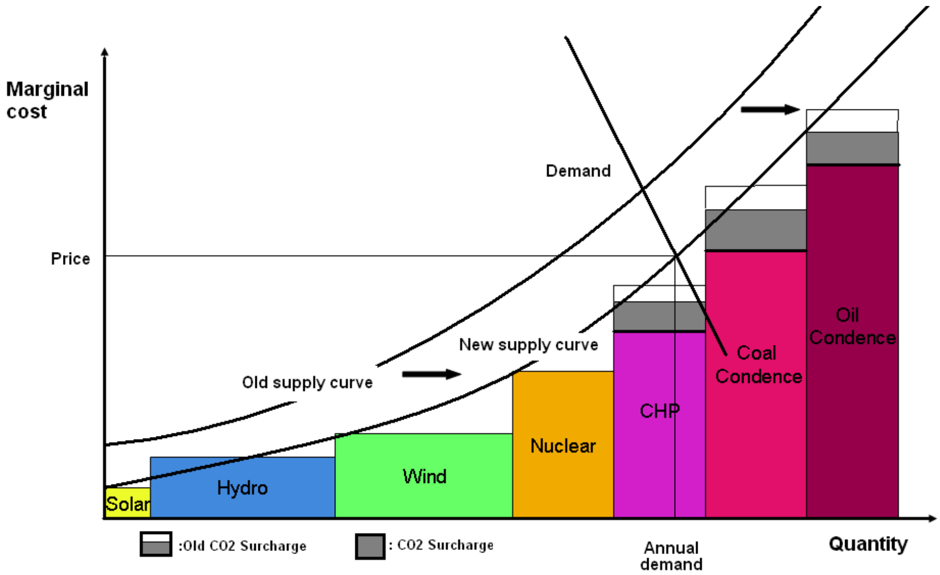

Figure 23: Imaginary Short-term Effect on Electricity Price of Adding Low Marginal Cost Renewable Power

In Figure 22 the electricity price is set by the coal condense, which is normally the case for example in the Nordic countries, although this depends greatly on the situation of hydropower. Therefore, if low-marginal-cost renewable power generation is added, this would in the short and medium-term shift the supply curve to the right as shown in Figure 23 and thus lower the price. According to a study by Sáenz de Miera, del Río et al. (2008) this direct effect could have been as high as 0.475 to 1.244 cents/kWh caused by wind power alone, between 2005 and 2007. Similar effects are noted by Böhme and Dürrschmidt (2008), who estimated that this direct effect could have been between 0.25

and 0.78 cents/kWh in Germany, between 2004 and 2006. However, it should be remembered that in the long run this effect might be diminished because of the need of peak load generation, which is at this moment quite often at least in part provided by coal or oil condense. Therefore, because for example wind energy is not highly capable of functioning in peak load generation, under the need for new investment the old equilibrium would be once again approached (Sáenz de Miera, del Río et al. 2008).

On the other hand, emission trade raises conventional power generation costs. This effect can be approximated by multiplying emission cost with the average emission factor of the power generation plant (Rathmann 2007). Therefore the increase of renewable power generation has an indirect downward effect on electricity prices because renewable energy cuts down carbon emissions by substituting conventional production. Thereby, the renewable power generation reduces the number of carbon dioxide allowances needed. This will reduce allowance prices and thus compliance cost, putting an additional downward pressure on the electricity price (Sáenz de Miera, del Río et al. 2008). This effect is presented in Figure 23 by cutting the total carbon dioxide surcharge. The size of this effect on total carbon market price is uncertain, but for example Rathman (2007) sees that it might be as high as 27%. Thus it might have reduced wholesale electricity prices in Germany by as much as 0.64 cent/kWh in 2005-2007 (Rathman 2007). Here we have to emphasise that this is of course relevant only in the areas where the environmental externality effect of greenhouse gas emissions is connected to electricity prices through for example emission trade.

Other indirect effects have been found as well that might provide a downward push on electricity retail prices. A study by Byrne (2007) pointed out that Renewable Portfolio Standards (RPS), which are the US green certificate system, might have actually decreased retail electricity rates over time, by reducing the demand of natural gas. Naturally, a similar effect would occur even with other conventional fuels that are used in power generation. There are also several estimation studies made about the direct effects of renewable energy promotion in the US. See Figure 24, which presents the review of 28 such studies. Among the studies, the median increase in retail electricity rates was 0.8 per cent, the largest estimated decrease impact was 5.2 per cent, and the highest increase estimate was 8.8 per cent (Chen, Wiser et al. 2008). Similar results are introduced in a study by (Wiser, Namovicz et al. 2007).

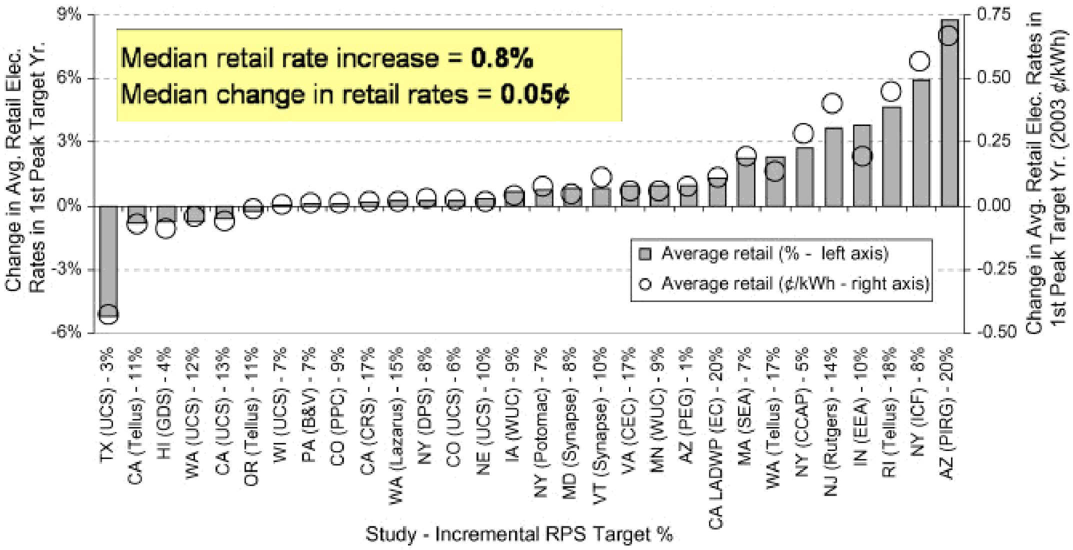

Figure 24: Renewable Energy Promotion Effect on Retail Price (Chen, Wiser et al. 2008)[52]

However, in the US case as well as in the European case, comprehensive empirical evidence has not yet been compiled. In quite a few instances it is not certain whether RPS is leading to higher or lower retail electricity prices, although lower prices are certainly possible (Wiser, Namovicz et al. 2007).

One important consideration is that the same effect caused by supporting low variable cost renewable energy would also surface if low marginal cost conventional energy would be supported (Green Stream Network 2007). Furthermore, studies above have compared the new situation with the old, where there was less production. Higher production has the natural effect of lowering the price. Hence, if other producers are not getting oversized wins at the moment, this kind of development might threaten their existence. Therefore, it should be strongly emphasised that this above mentioned shift also brings up the highly important question of peak load supply security, which should not be casually overlooked. It leads us to the question of what would happen to a healthy investment base if all new investments were done under a subsidy. Also, we have to consider what the effect is and who pays the new distribution challenges.

[52] Initial figure source: Lawrence Berkeley National Laboratory

Nevertheless, this issue is highly relevant and would be worth further examination. Furthermore, it would be very interesting to connect the whole renewable portfolio, the supply security, and distribution issues to these future studies as well.

7.6 A Technology Life Cycle Perspective Driving Renewable Energy Generation Policy Instruments

Right now, surrounded by climate concerns, energy security apprehensions, and fast-spreading economic recession, some researchers have begun to look for salvation from technology development. *"Innovation is the principal source of economic growth and a key source of new employment opportunities and skills, as well as providing potential for realising environmental benefits" (Foxon, Gross et al. 2005 pp.2124).* The renewable energy revolution would not be the same as the information technology revolution, which opened the way to a completely new industry. However, there is great potential for future wins waiting to be mobilised from the renewable energy system sector (Lund 2008). If we want to be able to boost technology development, we should improve our innovation policy processes (Foxon, Pearson 2008, Lund 2008). While the chapters above have mostly put an emphasis on how different policy instruments might effect the technology development process, this sub-chapter turns the coin and gives a short glimpse on how things would be if the technology were the one that decides how, when, and what policies are implemented. Challenges related to this task are manifold. Anticipated and needed new innovations would most likely end up "on the shelf". How could we boost the learning effects and at the same time be able to avoid the inferior technology lock-ins caused by path dependency? This is a subject that has been much studied, mostly from the viewpoint of environmentally-friendly technologies. However, in this chapter we concentrate mostly on the arguments put forward by Midttun and Gautesen (2007). This is because they give an interesting view to the renewable energy debate that might be worth further extensive study in the future.

What is the fuss about debating which instrument is better - feed-in tariff or green certificate? Midttun and Gautesen (2007) argue that these instruments should not be seen as competing alternatives, but rather as complementary regulatory instruments targeting subsequent steps in the product cycle. This kind of view is also emphasised in a study made by Foxon, Gross et al. (2005). They see that effective policy instruments should have an understanding of an innovation system that meets different challenges during each maturity stage. Thus the main idea enabling new technologies to triumph is to give multiple technologies a chance by helping them in the right way in each maturity stage (Sandén, Azar 2005, Foxon, Gross et al. 2005, Midttun, Gautesen 2007). Hence implementing the right kind of policies at the right time will play an important role, not least because for example research and development policies might be many times cheaper than economy-wide policies (Sandén, Azar 2005, Lund 2007).

In the early innovative phase of the product cycle, the focus should be on dynamic innovation-oriented policy instruments. Using this point of view, the stimulus of early deployment, following the research and development phase, might be best supported by targeted measures such as feed-in tariffs or specialised auctions. Tariffs could have the advantage of allowing differentiation and specific pricing of individual technologies, thus permitting simultaneous development of a broad spectrum of technologies. In later phases, where some technologies develop their cost-efficiency closer to that of established incumbent technology, certificate markets might provide a more adequate stimulus to further commercialisation before full competitiveness in the mainstream market is achieved. This way the new green technologies would be exposed to the general inter-technology competition and would have to win in this competition before being exposed to regular energy market competition in the next round (Midttun, Gautesen 2007). With this in mind, Midttun and Gautsen (2007) emphasise that the feed-in tariffs and the green certificate could be used to target different stages in the product cycle between early research and development and later full market deployment. They might therefore backup each other's failures. Even though effective, feed-in tariffs only expose the technology to a benchmark cost model for the relevant technology, sometimes even boosting sub-optimal conditions by, for example, giving extra support for wind power in locations with poor wind conditions (Midttun, Gautesen 2007). *"The certificate-market, on the other hand, exposes to cross-technology competition and gives no handicap-privilege" (Midttun, Gautesen 2007).*

So, at what stages are different technologies and when should technology go forward in the support scheme? To this question Midttun and Gautsen (2007) present an interesting option that uses learning curves. The idea is presented in Figure 25.

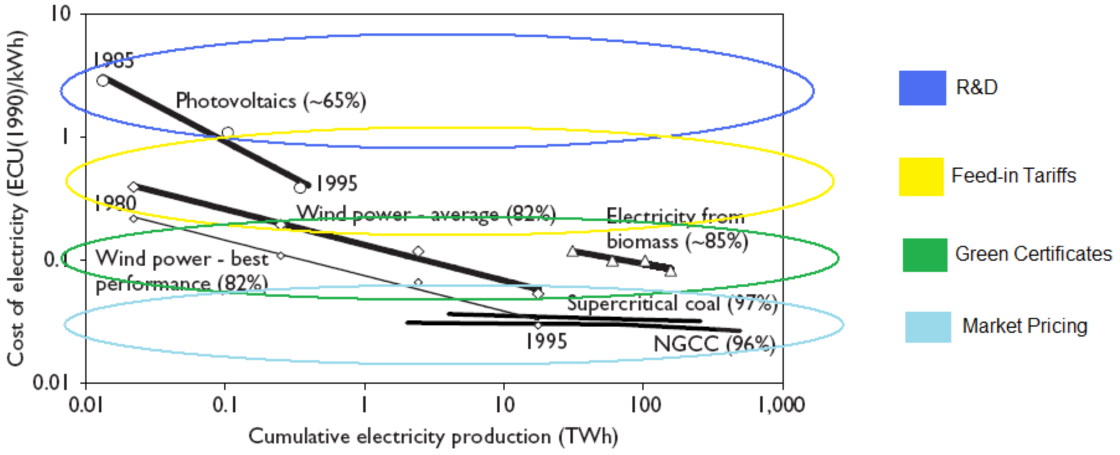

Figure 25: Complementary Support System Based on Learning Curves (IEA 2000) (Midttun, Gautesen 2007)

Highly uncertain learning curves are often seen to be the only way to predict technology development. Thus, they might be relevant tools to use if policy decision processes are centred around technology processes. However, there are big challenges with this kind of proceeding. It is very hard to know what the right size is of the circles are in figure 25, or in other words, when the right time is to change instrument? Furthermore, one of the greatest question-marks remains over whether the learning effect has taken place because of the time factor or because of volume, which is argued for in Figure 25. Forcing innovation might not be at least the most cost effective way to proceed (Lesser, Su 2008). This is hinted at by the price growth of wind turbines under European schemes as well as under the US Production Tax Credit scheme, which might have overheated the market (Green Stream Network 2007, Wiser, Bolinger et al. 2007). However, with the economies of scale and scope, it is the learning effect that will push the new technology prices down (Sandén, Azar 2005, Foxon, Gross et al. 2005, Midttun, Gautesen 2007). It would be highly interesting to see further studies about an integrated technology-focused approach in the debate on renewable energy technology policy instruments, as well as with the climate policy instruments debate. This is not least because in the field of climate policy many researchers have put a great deal of trust in humankind being able to develop in the long run a so-called backstop technology, which would change the direction of climate development (Nordhaus 2008, Popp 2006). However, regardless of whether the new innovation is either a new way of producing clean energy or a carbon eating plant, it still has to be invented first.

8 Conclusions

Summing up all the perspectives of policy instruments, it has become quite obvious that a sound political climate as well as energy intervention is needed to hinder market failures and furthermore to lead development in a more sustainable direction.

The primary objective of this thesis was to find relevant current research about climate policy and renewable energy policy instruments and to present what has been investigated in them. In order to analyse the research and academic debate, different criteria were introduced. Even though the criteria were used to carry through the selected sub-topics, there were issues that were left open, and for the reader to analyse. Deeper criteria analysis concerning individual research papers was mostly left for future study. Furthermore, as the issues explored were partly selected by my own subjective elaboration, presumably if the research were conducted by some other researcher, different issues may have been weighed and found important. Nevertheless, below are some important conclusions and recommendations for future study that can be made on the basis of this thesis.

The section on the economics of climate change presented several complicated issues concerning baseline scenarios, abatement costs, damage costs, and discount rates. It was emphasised that in the future there will be substantial costs arising out of abatement and adaptation. As to what the optimum balance between these two will be, we need more robust research. However, this should not work as a barrier to starting the action. Even if there was evidence of radical controversy between different academic studies, there was also a high degree of unanimity that climate change is a grave phenomenon that needs to be taken seriously. It is emphasised that we will hopefully be able to hear the proverbial alarm in climate policy issues before we have our back against the wall. To prevent this scenario we will primarily need political will, global as well as local cooperation, and wise decisions in the fifteenth Conference of Parties in Copenhagen at the end of 2009.

Policy instruments have everything to do with this. However, before this policy implementation stage, the desired targets should be rigorously examined and chosen. The principle of “one policy, one main target” should be emphasised. As Leonardo has summed it up “Simplicity is the highest form of sophistication.” It is obvious that every policy instrument has positive and or negative side-effects. However, many times these side-effects are emphasised even more than the direct effects, when promoting a certain instrument. Even though side-effects might be of great importance from a policy acceptance perspective, the main focus should be on the core issue. In the case of renewable energy generation policy instruments, the most natural target would be to enhance new technology penetration. In the case of climate policy instruments, then again, the target of choice would be to cut greenhouse gases.

Research conducted hitherto about climate policy and renewable policy instruments informs us that even though we have been locally taking steps towards carbon pricing, technology innovation boosting, and behavioural changes, there is still lot to do. The silver bullet of a single technology or policy leading us to the right track is yet to materialise. If the will were strong enough, raising the carbon price immensely could change the direction in climate policy issues as well as partly with renewable energy issues. However, this would end up having a bad influence on the economic and social fronts, and might ultimately destroy the willingness to further environmentally positive development. Hence to fight climate change it is important to make clever moves that drive us towards the right greenhouse gas prices, change human behaviour, and boost technological innovation.

Regarding international climate policy instruments, this thesis has highlighted that there is evidence that at least serious thought and research should be given to other policy instruments than emission trade. This is based on the fact that there are academic arguments that price mechanisms, either carbon tax or hybrid tax-quotas, should be preferred over emission trade, as they hold several advantages compared to emission trade, not least because of the supposed superior efficiency under uncertainty. For this reason, before locking in emission trade as the number one choice, it might be valuable to once again have a serious global discussion about the possible alternatives or major corrections for Kyoto instruments. This should not, however, postpone the important decisions that need to be made in the short run. Consequently, great effort should go into this matter as soon as possible. A good starting point for further study could be to begin analysing what factors caused the turnaround in the European Union, i.e. to drop carbon tax instruments, which were strongly considered prior to the Emission Trading Scheme, and are these factors still seen in the same way. In the case that conclusions lead to continuing with emission trade, there is evidence that by learning, adapting to new information from former experiences, and by correcting observed errors, emission trade can be made to function nicely as a climate policy.

With technological change, then again, we need to address non-economic barriers, with transparent and predictable policy instruments that are transitional, system friendly, and at least partly tailored to suit different technologies. Because conventional energies still have the strongest foothold in business we should not underestimate their need to survive. We should be able to integrate them, as well as those responsible for transmission lines, to push for change or at least acknowledge there is a need for some change. In reality this is being done at this very minute. There is a strong wind of change blowing in Europe. In 2008, wind energy set a new record by being the number one newly-installed power source in Europe. Some 40 % of all new power installations were wind power. However, this raises the question of to what extent new power investments made in the EU are subsidised. Are the policy instruments boosting renewables so hard that new healthily (natural merit order) cost-efficient investments are not being made at all? It has been pointed out that strong short-term subsidies for renewables might cause highly inefficient development and create costly bottlenecks. This has happened in the United States Production Tax Scheme and partly also with the European wind energy boost. These may be highly interesting tasks for further investigation. This is not least because it should be strongly stressed that this energy generation change should happen without jeopardising energy supply security.

As well as with climate policy, in the field of renewable energy generation the superiority of the instrument is greatly dependent on which criterion is emphasised the most. Furthermore, one has to remember that whichever instrument is chosen, the success of the instrument is mostly attributable to how well it is implemented. When comparing the feed-in tariff and green certificates, both instruments can be modified to look like each other. And modified instruments may even function much better than the basic or fundamental ones. In addition, positive qualities of other support instruments could be connected to these instruments to make them function even better. Because of the limits of the real world, one always has to make some compromises with the criteria and targets, since in the final analysis the consumer is the one paying the bill. Hence after the wise criteria weights are decided, whichever instrument or mix of instruments gives the smallest cost for the consumer should be selected.

Here harmonisation should be seen as one possible answer. However, it is unlikely that we will witness a harmonised EU-wide support scheme in the foreseeable future. The possible implementation of a harmonised system will constitute a huge challenge, regardless of which support system is chosen. Especially national green certificate schemes are highly differentiated and at this moment national schemes are seen to be diverging rather than becoming harmonised. However, when electricity markets move towards harmonisation, this subject might gather momentum once again. In the discussion of harmonisation, it would be important that price instruments such as feed-in tariffs should be given serious consideration as well, not least because arguments against the feed-in tariff lack empirical evidence. In the long run anything is possible. For example, before the 1990s in Scandinavia few would have thought that an integrated electricity market would come into being, and now when it exists, it is hard to imagine things any other way.

Climate policy and renewable energy generation policy instruments have strong effects on the way they each function. Climate policy and renewable energy generation policy instruments should not be seen as substitutes but as complementary to one another. Since they have strong interactions and effects on each other's operation and targets, it is important that when either of them is implemented, these interactions are emphasised, examined, and understood. An interesting future study would be to have a wider examination of this area by comparing different modifications to the climate policy and renewable energy generation instruments, and by analysing the cross-effects in these cases. In particular the carbon tax and hybrid instruments for both climate policy and renewable energy generation should be further studied.

Literature shows that renewable energy generation policy instruments clearly affect wholesale and retail electricity prices. However, more robust aggregate empirical research should be conducted the issue. Furthermore, it would be important to connect the whole new-renewable portfolio, supply security, and distribution issues to these future studies as well.

It would also be most interesting to see further studies about an integrated technology-focused approach, as was presented in the last sub-chapter. Attention should be paid to this in the debate on renewable energy technology policy instruments. Furthermore, this might be essential from the climate policy viewpoint in particular if some kind of backstop technology is sought. Equally, if a broad range of researchers and U.S. President Barack Obama are to be believed, this could have great impact on the economy as well: *"We know the country that harnesses the power of clean, renewable energy will lead the 21st century"* (Obama 2009).

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Appendix 1: Current Country Groupings under UNCCC, EU and OECD

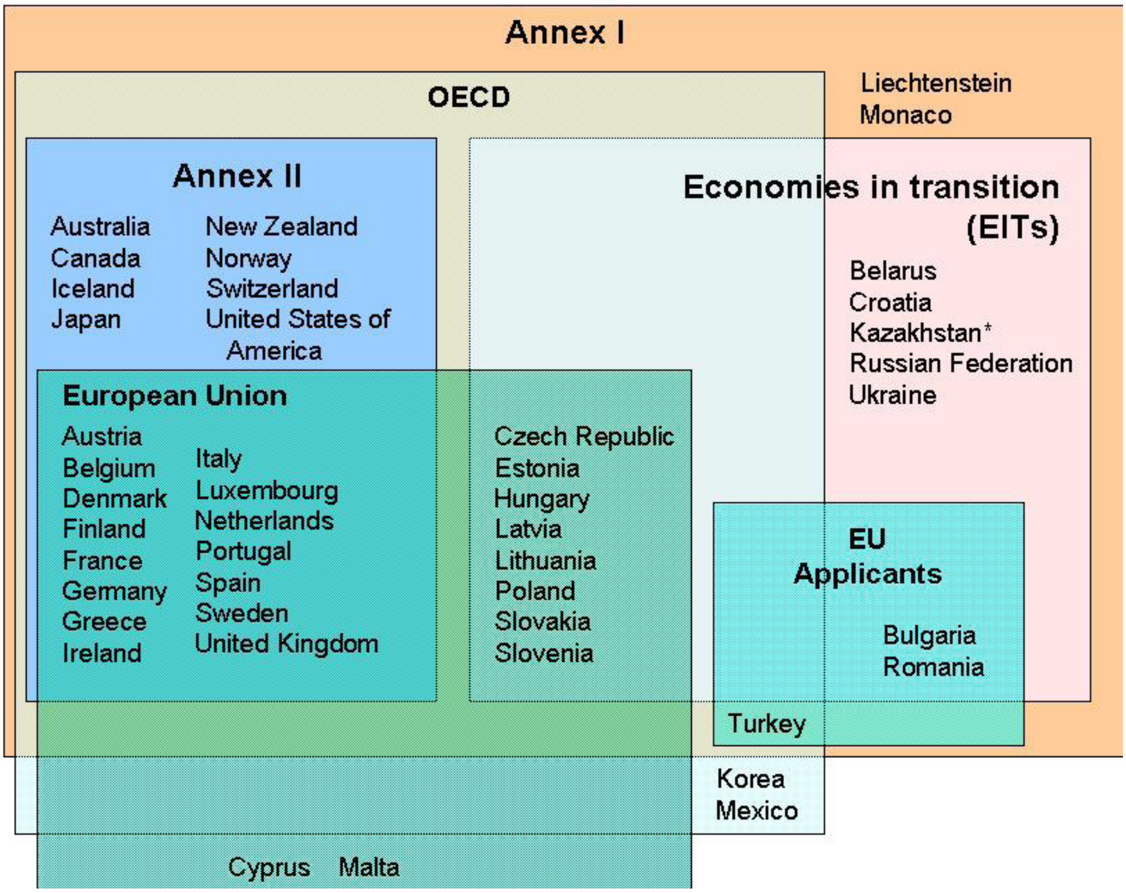

Figure 26: Current Country Groupings under UNCCC (Höhne, Phyllipsen et al. 2005)

Appendix 2: Annex B Countries and their Kyoto Protocol Emission Targets

Country	*Target (1990** - 2008/2012)*
EU-15, Bulgaria, Czech Republic, Estonia, Latvia, Liechtenstein, Lithuania, Monaco, Romania, Slovakia, Slovenia, Switzerland*	*-8%*
*US****	*-7%*
Canada, Hungary, Japan, Poland	*-6%*
Croatia	*-5%*
New Zealand, Russian Federation, Ukraine	*0*
Norway	*+1%*
Australia	*+8%*
Iceland	*+10%*

** The 15 States who were EU members in 1990 will redistribute their targets among themselves, taking advantage of a scheme under the Protocol known as a "bubble", whereby countries have different individual targets, but which combined make an overall target for that group of countries. The EU has already reached agreement on how its targets will be redistributed.*
*** Some EITs have a baseline other than 1990.*
**** The US has indicated its intention not to ratify the Kyoto Protocol.*
Note: Although they are listed in the Convention's Annex I, Belarus and Turkey are not included in the Protocol's Annex B as they were not Parties to the Convention when the Protocol was adopted.

Figure 27: Countries Included in Annex B to the Kyoto Protocol and Their Emissions Targets (UNFCCC 2008b)

Appendix 3: Finnish Energy Taxes

Table 14: Excise Tax Rates and Strategic Stockpile Fees in Finland (January 2008) (Ministry of the Environment 2008)

Fuel	Basic tax	Surtax (*=carbon comp., €20/tonne CO_2)	Strategic stockpile fee
Unleaded petrol, euro cents/litre - reformulated sulphur free - other grades	 57.24 59.89	 * 4.78 * 4.78	 0.68 0.68
Diesel oil, euro cents/litre - sulphur free - other grades	 30.67 33.32	 * 5.38 * 5.38	 0.35 0.35
Light fuel oil, euro cents/litre	2.94	* 5.41	0.35
Heavy fuel oil, euro cents/kg	-	* 6.42	0.28
Jet fuel (kerosene), euro cents/litre	33.32	* 5.38	0.35
Aviation gasoline, euro cents/litre	37.54	* 4.78	0.68
Coal, Euros/tonne	-	* 49.32	1.18
Peat	-	-	-
Natural gas, euros/MWh	-	* 2.016 (reduced rate)	0.084
Electricity, euro cents/kWh - rate I (households, services, agric.) - rate II (mining, manufacturing)	 - -	 0.87 0.25	 0.013 0.013
Pine oil (heating), euro cents/kg	6.70	-	-

*The environmental tax component (i.e. carbon surtax), based on the carbon content of fuels used for heating and transportation is, since January 2008, €20 per tonne of CO_2 (€75 per tonne of carbon).

Appendix 4: The United States State Rules, Regulations and Policies for Renewable Energy

Table 15: Summary of State Rules, Regulations and Policies Used in the United States for Renewable Energy (North Carolina State University 2008)

Rules, Regulations, & Policies for Renewable Energy

State	PBF	Disclosure	RPS	Net Metering	connection	Exten. Analysis	Contract. License	Equip. Certific.	Access Laws	Constr. & Design
Alabama										
Alaska									1-S	
Arizona			1-S	1-S 3-U	1-U	1-S	1-S	1-S	1-S	3-S 2-L
Arkansas				1-S	1-S					1-S
California	1-S	1-S	1-S	1-S	1-S		1-S		2-S 8-L	1-S 6-L
Colorado	1-L	1-S	1-S 1-L	1-S	1-S	1-S			1-S 2-L	2-S 5-L
Connecticut	1-S	1-S	1-S	1-S	1-S		1-S			1-S
Delaware	2-S 1-U	1-S	1-S	1-S	1-S					
Florida		1-S	1-U	1-S 7-U	1-S		1-S	1-S	1-S 1-L	1-S
Georgia				1-S	1-S				1-S	
Hawaii			1-S	1-S	1-S		1-S		1-S	2-S
Idaho				3-U					1-S	
Illinois	1-S	1-S	1-S	1-S	1-S					1-S
Indiana				1-S	1-S				1-S	1-S
Iowa		1-S	1-S	1-S	1-S				1-S	
Kansas									1-S	1-L
Kentucky				1-S					1-S	
Louisiana				1-S 1-L	1-S					
Maine	1-S	1-S	1-S	1-S					1-S	1-S
Maryland		1-S	1-S	1-S	1-S				1-S	3-S
Massachusetts	1-S	1-S	1-S	1-S	1-S				1-S	3-S
Michigan	1-S	1-S	1-S 1-U	1-S	1-S		1-S			2-S 1-L
Minnesota	1-S	1-S	2-S	1-S	1-S			1-S	1-S	1-S
Mississippi										
Missouri			1-S 1-L	1-S	1-S				1-S	1-S
Montana	1-S		1-S	1-S 1-U	1-S				1-S	
Nebraska				1-U					1-S	
Nevada		1-S	1-S	1-S	1-S		1-S		1-S	1-S
New Hampshire			1-S	1-S	1-S				1-S	1-L
New Jersey	1-S	1-S	1-S	1-S	1-S				2-S	2-S
New Mexico			1-S	1-S 1-U	1-S	1-S			1-S	1-S
New York	1-S	1-S	1-S 1-U	1-S	1-S				1-S	1-S 1-L
North Carolina			1-S	1-S	1-S				1-S 1-L	1-S 7-L
North Dakota			1-S	1-S					1-S	
Ohio	1-S	1-S	1-S	1-S 1-U	1-S				1-S	1-S
Oklahoma				1-S						1-S
Oregon	1-S	1-S	1-S	1-S 1-U	1-S		1-S		1-S 2-L	1-S 1-L
Pennsylvania	1-S	1-S	1-S	1-S	1-S					1-S
Rhode Island	1-S	1-S	1-S	1-S					1-S	1-S
South Carolina				3-U	1-S					1-S
South Dakota			1-S							1-S
Tennessee									1-S	
Texas		1-S	1-S 1-U 1-L	1-S 1-U	1-S	1-S				2-S 6-L
Utah			1-S	1-S 3-U	1-S		1-S		1-S	1-L
Vermont	1-S		1-S	1-S	1-S					
Virginia		1-S	1-S	1-S	1-S				2-S	1-S 1-L
Washington		1-S	1-S	1-S 1-U	1-S				1-S	1-S 1-L
West Virginia				1-S						
Wisconsin	1-S		1-S	1-S	1-S		1-L		1-S 1-L	1-S
Wyoming				1-S	1-S					
District of Columbia	1-S	1-S	1-S	1-S	1-S					1-S
Palau										
Guam			1-S	1-S						1-S
Puerto Rico				1-S				1-S		
Virgin Islands				1-S					1-S	
N. Mariana Islands										
American Samoa										
Totals	21	23	43	72	38	4	10	4	53	80

F = Federal S = State/Territory L = Local U = Utility